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CONTENTS.

CORRECTION.

REVIEW, AUGUST, 1923:

Page 389, in the heading of Table 4, "centimeters" ***should be*** **"millimeters."**

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THE LAW OF PRESSURE RATIOS AND ITS APPLICATION TO THE CHARTING OF ISOBARS IN THE LOWER LEVELS OF THE TROPOSPHERE.

C. LeRoy Meisinger, Meteorologist.

[Weather Bureau, Washington, D. C., August 3, 1923.]

INTRODUCTION.

The solution of many problems of theoretical and practical meteorology is hindered by a lack of information concerning the simultaneous vertical and geographical distribution of certain meteorological elements. One of these elements, barometric pressure, has always been regarded as of supreme importance in weather forecasting; and, with the increasing availability of aerological data, there has developed a belief that barometric conditions at certain free-air levels may possess prognostic value with respect to surface weather. The elevation of these strategic levels is not definitely known, but the importance of the problem and the significance of the possible results abundantly justify an attempt to ascertain the nature of horizontal barometric distributions at the greatest possible heights in the atmosphere.

It is a relatively easy matter to secure information concerning the vertical distribution of meteorological elements at a small number of aerological stations; but it is difficult to produce daily charts of the geographical distribution of these elements. Recently published papers have attempted to achieve this result for the levels 1 and 2 kilometers (3,281 and 6,562 feet) above sea level,[1] and subsequent study of the accuracy of the maps thus produced indicates that they are reliable.[2]

The attainment of this objective, however, serves only as a stimulus to the accomplishment of similar results for higher levels. Yet, one encounters difficulties owing to paucity of data, in attempting to extend the original method to levels higher than 2 kilometers above sea level. It has seemed that a more fruitful field might be found in dealing directly with pressures than with the estimation of air-column temperatures to such great heights. In other words, previous studies have provided a means of securing a knowledge of the barometric distribution at 1 and 2 kilometers above sea level. Is it possible, with the pressure at these two levels, in addition to the precisely-measured surface pressure, to learn something about the pressure distribution at a fourth, and higher, level? The present paper seeks an answer to this question.

PRELIMINARY CONSIDERATIONS.

Ratios between pressures at different free-air levels.—In order to secure a foothold for an attack upon this problem, mean monthly free-air pressures for various levels and for the several aerological stations of the Weather Bureau were examined. It was found that if a ratio is formed between the pressure at some high level, p_z, and the surface, p_s, and between the pressure at 2 kilometers above sea level, p_2, and 1 kilometer above sea level, p_1,

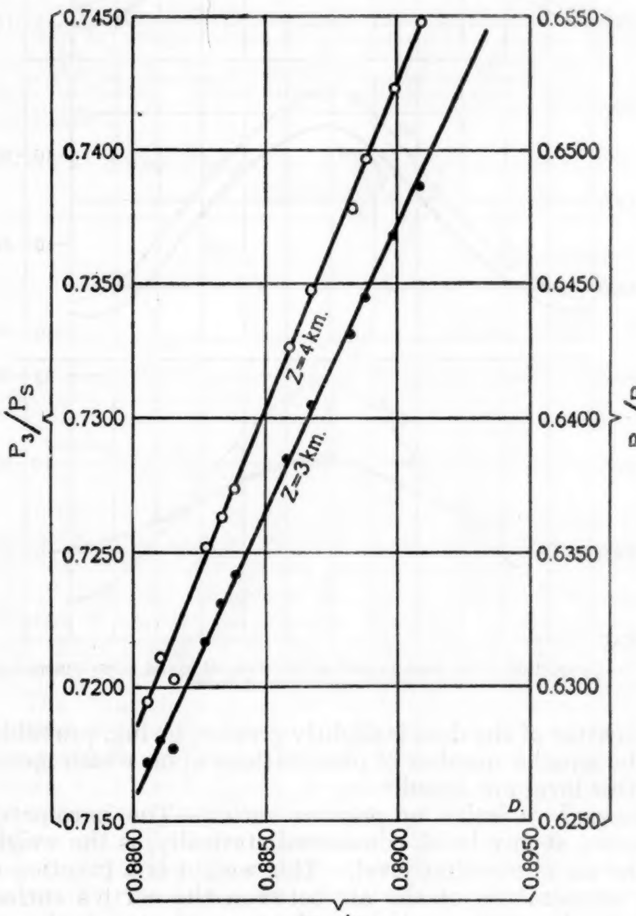

FIG. 1.—The relation between p_z/p and p_2/p_1 (annual means) at Drexel, Nebr.

the ratio p_z/p_s stands in an apparently linear relation to p_2/p_1. In other words,

$$p_z/p_s = (ap_2/p_1) + b,$$

in which a and b are constants. Thus, if p_s, p_1, p_2, a, and b were known, p_z could readily be computed from the equation

$$p_z = p_s[(ap_2/p_1) + b] \text{..................} (1)$$

Should such a simple relation hold for pressures at any time, as well as for monthly means, it is seen at once that

[1] Meisinger, C. LeRoy: The preparation and significance of free-air pressure maps for the central and eastern United States. Mo. Weather Rev. Supplement No. 21, Washington, 1922.

[2] *Ibid.* Concerning the accuracy of free-air pressure maps. Mo. Weather Rev., April, 1923, pp. 190-199.

here is a method of great promise for computing free-air pressures at high levels upon the basis of surface conditions only.[3]

Figure 1 shows for the Drexel (Nebraska) aerological station the relation between these ratios when z is respectively 3 and 4 kilometers (9,842 and 13,123 feet) above sea level. For these two levels the points lie very close to the line of best fit, but, in considering a similar relation for the 5-kilometer (16,404-foot) level,

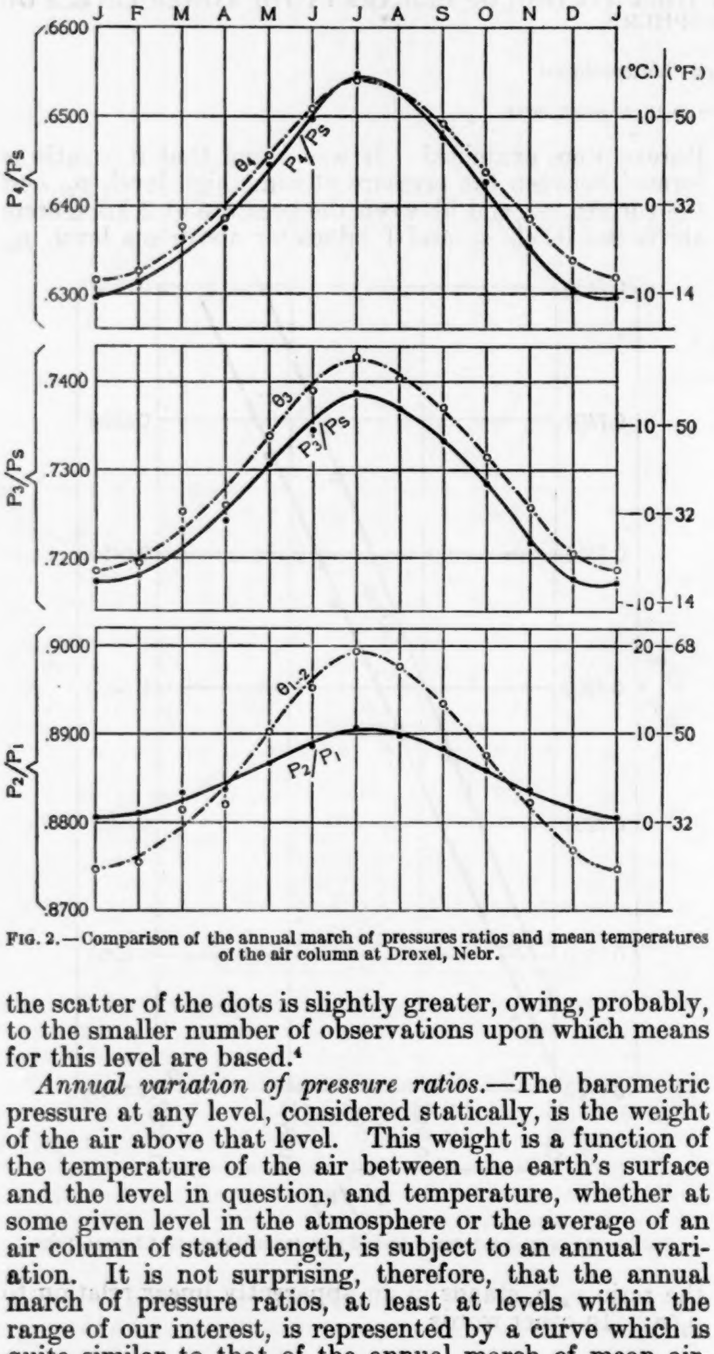

FIG. 2.—Comparison of the annual march of pressures ratios and mean temperatures of the air column at Drexel, Nebr.

the scatter of the dots is slightly greater, owing, probably, to the smaller number of observations upon which means for this level are based.[4]

Annual variation of pressure ratios.—The barometric pressure at any level, considered statically, is the weight of the air above that level. This weight is a function of the temperature of the air between the earth's surface and the level in question, and temperature, whether at some given level in the atmosphere or the average of an air column of stated length, is subject to an annual variation. It is not surprising, therefore, that the annual march of pressure ratios, at least at levels within the range of our interest, is represented by a curve which is quite similar to that of the annual march of mean air-column temperature.

Figure 2 shows the annual march of the several pressure ratios shown in Figure 1, together with the annual march of the mean temperature of the air column pertinent to the particular pressure ratios. The intimate relation that exists between the several curves illustrates clearly the functional relation between temperature and free-air pressure. It will be remembered that in the central and eastern United States the annual march of barometric pressure at the surface is characterized by a minimum in late spring or early summer and a maximum in early winter, characteristics that do not appear either in the annual march of temperature or in the annual march of pressure ratios.

Having considered the monthly mean pressures thus briefly, one's curiosity is whetted by the rather astonishing fact that data which are ordinarily so accurately represented by the exponential law should now appear in linear guise. What is the true nature of this curve which expresses the relation between p_z/p_s and p_2/p_1? The answer to this question can be most readily obtained from theory.

THEORETICAL RELATIONS.

The slope of the curve $y=f(x)$.—The hypsometric relation, the fundamental law in all considerations of this character, may be stated as follows:

$$p_z = p_s \exp \frac{-Z_z}{K\,(1+\alpha\theta_z)} \qquad (2)$$

in which p_z and p_s are the barometric pressures at some level in the atmosphere and at the surface, respectively; Z_z is the vertical distance between the point where p_s is measured and the level for which p_z is to be determined, generally known as the length of the air column; K is a constant; α is the coefficient of gas expansion; and θ_z is the virtual mean temperature of the air column.

Since we are interested in the ratio of pressure at some high level to the pressure at the surface, let

$$y = p_z/p_s.$$

Upon substituting the expression for p_z contained in (2) it is found that

$$y = \exp \frac{-Z_z}{K\,(1+\alpha\theta_z)}.$$

While, in ordinary practice, one is interested in some particular level, in which case Z_z would be a parameter, it is best here to consider both θ_z and Z_z as variables. Hence, differentiating, one obtains:

$$dy = \left(\exp \frac{-Z_z}{K(1+\alpha\theta_z)}\right) \frac{Z_z \alpha d\theta_z - (1+\alpha\theta_z) dZ_z}{K(1+\alpha\theta_z)^2} \qquad (3)$$

Again, let p_m and p_n represent the barometric pressure at two other levels in the atmosphere, and let

$$x = p_m/p_n$$

From (2), as before, it is known that,

$$p_m = p_n \exp \frac{-Z_{m-n}}{K(1+\alpha\theta_{m-n})}$$

whence,

$$x = \exp \frac{-Z_{m-n}}{K(1+\alpha\theta_{m-n})}.$$

Since it is desired to allow the stratum of atmosphere between the bounding surfaces of which Z_{m-n} lies to

[3] It will be recalled that the method for obtaining pressures at 1 and 2 kilometers above sea level makes use only of current pressure, temperature, and wind direction *at the surface*.

[4] All averages of free-air conditions used in this paper have been taken from "An aerological survey of the United States: Part I. Results of observations by means of kites," by W. R. Gregg. MO. WEATHER REV. SUPPLEMENT No. 20, Washington, 1922.

remain fixed regardless of the variations of Z_z, Z_{m-n} may be properly regarded as a parameter, and differentiation will yield the equation,

$$dx = \frac{Z_{m-n}\alpha}{K(1+\alpha\theta_{m-n})^2} \exp \frac{-Z_{m-n}}{K(1+\alpha\theta_{m-n})} d\theta_{m-n} \quad \text{- - - - - (4)}$$

Dividing (3) by (4) one obtains the slope of the curve representing the relation between y and x:

$$\frac{dy}{dx} = \left(\exp \frac{Z_{m-n}(1+\alpha\theta_z) - Z_z(1+\alpha\theta_{m-n})}{K(1+\alpha\theta_z)\,(1+\alpha\theta_{m-n})}\right) \times$$

$$\frac{(1+\alpha\theta_{m-n})^2}{(1+\alpha\theta_z)^2} \times \frac{Z_z d\theta_z - (1+\alpha\theta_z dZ_z)}{Z_{m-n} d\theta_{m-n}} \quad \text{- - - - - - - (5)}$$

In case it is desired to treat Z_z as a parameter, the equation (5) is simplified, (since $dZ_z = 0$) to

$$\frac{dy}{dx} = \left(\exp \frac{Z_{m-n}(1+\alpha\theta_z) - Z_z(1+\alpha\theta_{m-n})}{K(1+\alpha\theta_z)(1+\alpha\theta_{m-n})}\right) \times$$

$$\frac{Z_z(1+\alpha\theta_{m-n})^2}{Z_{m-n}(1+\alpha\theta_z)^2} \times \frac{d\theta_z}{d\theta_{m-n}} \quad \text{- - - - - - - - - - - - - (5a)}$$

It is clear from equations (5) and (5a) that the curve representative of the relation between x and y can not be a straight line, as was at first suspected, but a curve whose slope is an exponential function involving the length and the mean temperature of the two air columns. If the original function were linear, the first differential would, of course, be a constant. The conclusion must be that within the limits of variation of the several variables in these equations, the variation of dy/dx is perhaps small enough to be negligible. This may be investigated by means of reasonable substitutions in these equations.

There occurs, moreover, in these equations, the term $d\theta_z/d\theta_{m-n}$ which one may interpret as the change of the mean temperature of the air column of length Z_z relative to the mean temperature of the air column of length Z_{m-n}. Since temperature varies so irregularly with altitude and time, it is obvious that the value of $d\theta_z/d\theta_{m-n}$ must vary almost incessantly in a most irregular manner. If the value of Z_{m-n} is chosen to be 1,000 meters (3,281 feet) and θ_{m-n} the mean temperature of this stratum which lies between 1,000 and 2,000 meters above sea level (3,281 to 5,562 feet), it seems reasonable that, for stations in the central and eastern United States, this stratum would occupy a relatively intermediate position in the stratum between the surface and some high level such as 3, 4, or 5 kilometers (9,842, 13,123, and 16,404 feet) above sea level. One should expect that temperature changes within the stratum (m-n) would proceed at about the same rate as within a stratum extending from the surface to, say, 3 kilometers above sea level (13,123 feet), and that, on the average, they would be relatively more rapid as higher and higher levels are considered as upper boundaries to the thicker air stratum. If, therefore, one wishes to assume a value for the fraction $d\theta_z/d\theta_{m-n}$, it would appear that for the 3-kilometer level (9,482-foot) the value 0.90 is appropriate, for the 4-kilometer level (13,123-foot) the value 0.80, and for the 5-kilometer level (16,404-foot) the value 0.65. (Attention is invited to the fact that the arbitrary assumption of a numerical value of $d\theta_z/d\theta_{m-n}$, while perhaps not serving to compute strictly accurate values of dy/dx, will not operate to influence the form of the curve.) Making the appropriate assumptions as to temperature, table 1 contains the results of computation from equation (5a) of values of dy/dx for several lengths of air column.

TABLE 1.—*Values of dy/dx computed from equation (5a) for various temperatures and lengths of air column and assumed values of $d\theta_z/d\theta_{1-2}$.*

Assumed mean temperature of air column (°C.).				Length of air column (meters).		
θ_{1-2}	θ_3	θ_4	θ_5	3,000	4,000	5,000
−22	−23	−25	−27	2.069	2.164	1.937
4	2	0	−2	2.136	2.260	2.045
30	27	25	23	2.190	2.340	2.141

It is seen that the values of dy/dx are very close to 2.000 and that the variation is not great. This may be seen more clearly if one examines the actual variation of angle of slope of the line representing the relation between x and y. For any given level the slope increases with increase of temperature, hence the difference between the angles of slope corresponding to the extremes of temperature will indicate the degree of curvature likely to be encountered in the curve of the original function. These angles and their differences appear in Table 2.

TABLE 2.—*Slopes of tangents to curve of $y=f(x)$ at temperature extremes, and their differences.*

θ_{1-2} (°C.)	Slope of tangent.					
	3,000 meters.		4,000 meters.		5,000 meters.	
	°	′	°	′	°	′
−22	64	12	65	12	62	42
30	65	28	66	51	64	58
Difference	1	16	1	39	2	16

It can be seen at once that the difference between a straight line and a portion of a curve the maximum curvature of which would produce an angle of the order of 2° between tangents at its extremes is negligible. Figure 3 shows the relation between dy/dx and θ_{1-2} for the three levels. On the left-hand scale are values of dy/dx and on the right-hand scale are angles of slope.[5]

The conclusion to be drawn from these considerations is that *within the limits of natural variation of the mean temperature of the air columns involved, the relation between P_z/P_s and P_m/P_n is practically linear, when these pressures occur within the lowest 5 kilometers of the atmosphere; and, therefore, that an equation of that form may be employed for the computation of one of the pressures when the remaining three are known.* For convenience, this may be referred to as the Law of Pressure Ratios.

OBSERVATIONAL DATA.

Nature of the data.—The data employed in this study were obtained from the original records on file in the Aerological Division of the Weather Bureau. They include observations made at each of the aerological stations which have been, or are being, operated by the Weather Bureau.

[5] The apparently nonuniform change of the values of dy/dx with change of Z_z is chiefly the result of the value of $d\theta_z/d\theta_{1-2}$ chosen for the several levels. If it were not for the assumed decrease of $d\theta_z/d\theta_{1-2}$ with increase of elevation, the several curves in figures 3 should lie one above another in the order of the level for which they are characteristic. But since this factor is assumed to decrease with elevation, the 5-km. curve and the 3-km. curve both lie below the 4-km. curve. Since the law of variation of $d\theta_z/d\theta_{1-2}$ with Z_z is not known, it is not possible at this stage of the paper to verify the assumed values of the factor.

In order to render the results of this paper comparable with those of previous investigations on kindred phases of this subject, all the observations selected were made at approximately 8 a. m., 75th meridian time. Certain corrections, devised to yield pressure values which probably would have been measured had it been possible to make simultaneous observations at all levels, were employed. However, cases in which the surface pressure was changing rapidly during the kite flight were not used owing to the unreliability of extrapolating the pressures

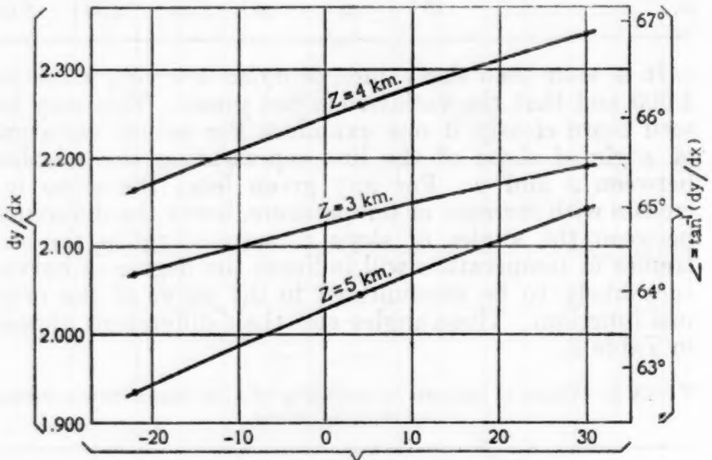

FIG. 3.—Relation between the mean temperature of the stratum of 1 kilometer thickness and the slope of the curve $y=f(x)$.

under such conditions. In other words, the pressure values from which ratios were formed are believed to be truly representative of simultaneous pressure conditions at all levels.

Having secured these data, ratios were formed between the pressures at 1 and 2 kilometers (3,281 and 6,562 feet) above sea level ($x=p_2/p_1$), and between pressures at the surface and some selected higher level ($y=p_z/p_s$). The higher levels thus selected were 3, 4, and 5 kilometers (9,842, 13,123, and 16,404 feet) above sea level, and, for each station, the investigation was carried as high as the amount of data justified.

Number of observations.—Table 3 gives the number of observations upon which the results of the portion of the paper employing current observations are based.

TABLE 3.—*Number of observations upon which results of current observations are based.*

Station.	With reference to level— 3 km. above m. s. l.	4 km. above m. s. l.	5 km. above m. s. l.
Ellendale, N. Dak.	72	79	....
Drexel, Nebr.	103	103	33
Broken Arrow, Okla	72	....	....
Groesbeck, Tex	90	62	....
Royal Center, Ind.	83	34	....
Mount Weather, Va.	91	91	38
Due West, S. C.	72	34	....
Leesburg, Ga.	45	....	....

These figures do not represent all available data in certain cases, especially with reference to the 3-kilometer level, but it is believed that they were sufficiently numerous to show accurately the relationships involved. This fact was obvious when the data were plotted in the form of dot charts. It is true, however, in the case of the 5-kilometer level that there were too few observations at most stations, and for that reason only Drexel and Mount Weather were used.

It is obviously unnecessary to reproduce all the dot charts. One is given in Figure 4, in order that the reader may see a typical example of the manner in which the observations distribute themselves. This type of distribution is characteristic of all stations and all levels.

Values of the constant a for aerological stations.—Having the data thus prepared and plotted, the line of good fit to the data—assuming, as was shown to be justified in the previous section, that a straight line adequately

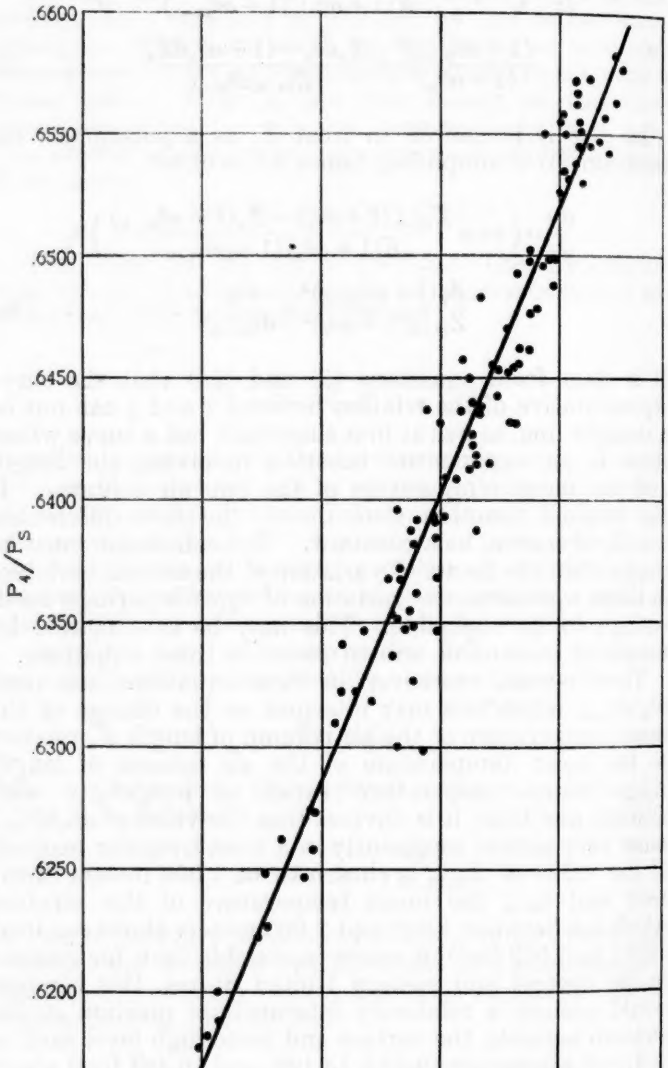

FIG. 4.—Distribution of individual observations about a line of good fit. Data from Royal Center, Ind.

represents the relationship between x and y—was determined by the ordinary method of least squares. This involves the evaluation of the two constants in the linear equation

$$y=ax+b,$$

in which x and y have the same significance as in the previous section, namely, $x=p_2/p_1$ and $y=p_z/p_s$.

The values of the constant a, where $a=dy/dx$, the slope of the line, were determined by the equation common in statistical procedure:

$$a = dy/dx = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$$

in which n is the number of observations. Table 4 contains the values of this constant.

TABLE 4.—*Values of the constant a, determined by the method of least squares.*

Station.	With reference to level—		
	3 km. above m. s. l.	4 km. above m. s. l.	5 km. above m. s. l.
Ellendale, N. Dak.	2.003	2.263	....
Drexel, Nebr.	1.916	2.336	1.994
Broken Arrow, Okla.	1.976	....	....
Groesbeck, Tex.	2.425	2.867	....
Royal Center, Ind.	2.025	2.238	....
Mount Weather, Va.	1.935	2.206	1.879
Due West, S. C.	1.928	2.113	....
Leesburg, Ga.	2.710	....	....

Values of the constant b for aerological stations.—The values of the second constant in the linear equation were determined by means of the following equation:

$$b = \frac{y - a(\Sigma x)}{n}$$

in which the values of a were those contained in Table 4. The following table contains the resulting values of b.

TABLE 5.—*Values of the constant b, determined by the method of least squares.*

Station.	With reference to level—		
	3 km. above m. s. l.	4 km. above m. s. l.	5 km. above m. s. l.
Ellendale, N. Dak.	−1.0423	−1.3594	....
Drexel, Nebr.	−0.9696	−1.4275	−1.2016
Broken Arrow, Okla.	−1.0357	....	....
Groesbeck, Tex.	−1.4414	−1.9161	....
Royal Center, Ind.	−1.0804	−1.3532	....
Mount Weather, Va.	−0.9744	−1.3024	−1.0911
Due West, S. C.	−0.9946	−1.2427	....
Leesburg, Ga.	−1.6987	....	....

Probable errors of single computations by the linear equation.—With the constants thus determined it is possible to form equations, characteristic of the various levels and several aerological stations, and to compute, using the original observed values of p_s, p_1, and p_2, values of p_z. In this way, values of the probable error of a single computation were derived, and these values are contained in Table 6. The equation for probable error was the one customarily used:

$$r = \pm .6745\ \sqrt{\Sigma v^2/(n-1)}$$

in which v is the difference between a computed and an observed value of p_z.

TABLE 6.—*Values of the probable error of a single computation of pressure at stated free-air levels based upon empirical equations derived above. (Inches).*

Station.	With reference to level—		
	3 km. above m.s. l.	4 km. above m. s. l.	5 km. above m. s. l.
Ellendale, N. Dak.	±0.027	±0.050	....
Drexel, Nebr.	±0.038	±0.047	±0.052
Broken Arrow, Okla.	±0.032	....	....
Groesbeck, Tex.	±0.041	±0.042	....
Royal Center, Ind.	±0.030	±0.041	....
Mount Weather, Va.	±0.027	±0.038	±0.054
Due West, S. C.	±0.034	±0.039	....
Leesburg, Ga.	±0.036	....	....
Mean	±0.033	±0.043	±0.053

The probable error of a.—From equation (1) it follows, if p_s, p_2, and p_1, are regarded as free from error, that

$$dp_z = (p_s p_2 da/p_1) + p_s db \ldots\ldots\ldots\ldots (6)$$

But since

$$b = \frac{(\Sigma y) - a(\Sigma x)}{n}$$

$$db = -(\Sigma x)da/n \ldots\ldots\ldots\ldots (7)$$

whence,

$$dp_z = (p_s p_2 da/p_1) - p_s[(\Sigma x)da/n]$$

$$= [(p_s p_2/p_1) - p_s(\Sigma x)/n]da$$

and

$$da = dp_z/[(p_s p_2/p_1) - p_s(\Sigma x)/n] \ldots\ldots (8)$$

Now, one of the laws of the propagation of error states that [6] if $Z = Az$, in which A is a constant, then,

$$R = Ar$$

in which R is the probable error of Z and r is the probable error of z. It will be seen that this equation is of the same form as (8).

Since it is desired only to obtain an idea of the order of magnitude of the error in a, and since a is to be used without respect to season, it is possible to substitute for dp_z the average probable error for the several levels contained in the last line of table 6, mean annual values of p_s, p_1, and p_2 for a representative station, and representative values of $\Sigma x/n$ obtained from the computation sheets. In this way we may regard da as the probable error of a, and it proves to be, on the average,

$$\text{for the} \begin{cases} \text{3-km. level, } \pm 0.0012. \\ \text{4-km. level, } \pm 0.0016. \\ \text{5-km. level, } \pm 0.0020. \end{cases}$$

Thus, since nearly all the values of a are very close to 2.000, it is seen that the values as stated to three decimal places in Table 4 are justified.

[6] Merriman, Mansfield: *Method of least squares.* New York, 1915, p. 77.

The probable error of b.—Having the above values for a, it is now a simple matter to substitute in equation (7) and compute the probable error of b. These values prove to be:

$$\text{for the}\begin{cases}\text{3-km. level,} & \pm 0.000008.\\ \text{4-km. level,} & \pm 0.000010.\\ \text{5-km. level,} & \pm 0.000013.\end{cases}$$

Conclusions concerning probable errors.—An interesting and highly pertinent fact becomes apparent upon consideration of the probable errors shown above: The large probable errors occur in the less significant member of this pair of constants. For example: When the angle of slope is close to 60°, as is the case here, a variation of one unit in the second decimal place of a implies a difference of slope of only about 7′. This is negligibly small. But a very slight variation in the value of b means that every ordinate will be in error by just that amount; or, to consider it geometrically, the entire line which represents the relation between x and y will be shifted parallel to itself by the amount of the error. These facts are important in attempting to carry over to the nonaerological stations the determination of these constants.

Another method of determining b.—The foregoing discussion has been built wholly upon the groups of current kite observations selected to represent the various levels and stations. The reliability of the values of the constants obtained by least-square analysis is dependent upon how closely the selected observations, taken in the aggregate, represent any observation that has been or will be made at a given station with respect to a given level. In other words, how closely does the mean of a given group of observations resemble the annual mean of the same elements based upon all the observations that are available, when the annual mean is also representative of conditions at 8 a. m., 75th meridian time?

It is evident that the graphical representation of the relation between x and y, should be a line passing through the annual mean corresponding to the same time of day.

It is stated by Mr. W. R. Gregg [7] that —

* * * The average time of the kite flights is such that the mean values of the meteorological elements at the surface are very nearly the same as the 24-hour averages. The differences are, in general, so small that it is deemed unnecessary to publish them in detail * * *.

Now, from Bigelow,[8] it is possible to obtain figures for correcting the 24-hour mean (annual) to the 8 a. m. mean (annual) and the corrected means are given in the following table. The corrections given by Bigelow are, of course, for the surface only, but since from (2),

$$dp_z = \exp \frac{-Z_z}{K\,(1+\alpha\vartheta_z)}\,dp_s$$

we can compute quite satisfactory values of the correction to be applied for the higher levels, we may reduce all the annual means for 24 hours to the annual means for 8 a. m.

[7] *Op. cit.*, p. 3.
[8] Bigelow, Frank H.: *Report on the barometry of the United States, Canada, and the West Indies.* Report of the Chief of the Weather Bureau, 1900-1901, Table 27, pp. 140-164.

TABLE 7.—*Annual mean pressures at the surface and several free-air levels. (8 a. m.) (mb.).*

Station.	Surface.	1 km.	2 km.	3 km.	4 km.	5 km.
Ellendale, N. Dak	963.3	899.5	795.2	701.4	617.3	541.7
Drexel, Nebr	969.5	901.0	797.7	704.7	621.4	546.9
Broken Arrow, Okla	989.7	903.4	801.5	709.4	627.0	551.6
Groesbeck, Tex	1,000.7	904.5	803.2	711.7	629.0	554.3
Royal Center, Ind	991.4	902.8	798.8	705.6	621.7	546.5
Mount Weather, Va	956.3	903.1	799.2	705.7	621.7	545.7
Due West, S. C	994.3	905.4	802.6	710.2	627.0	....
Leesburg, Ga	1,009.4	906.7	804.6	712.9	630.4	554.0

From these data it is possible to derive values of x, (p_2/p_1), and y, (p_z/p_s), and the values of these ratios are given in Table 8.

TABLE 8.—*Values of x and y for the annual mean at various aerological stations and for various levels.*

Station.	p_2/p_1	p_3/p_s	p_4/p_s	p_5/p_s
Ellendale, N. Dak	0.8840	0.7281	0.6408	0.5623
Drexel, Nebr	0.8853	0.7269	0.6409	0.5641
Broken Arrow, Okla	0.8872	0.7168	0.6335	0.5573
Groesbeck, Tex	0.8880	0.7112	0.6286	0.5539
Royal Center, Ind	0.8848	0.7117	0.6271	0.5512
Mount Weather, Va	0.8849	0.7379	0.6501	0.5706
Due West, S. C	0.8865	0.7143	0.6306	....
Leesburg, Ga	0.8874	0.7063	0.6245	0.5488

Now, from equation (1) we know that

$$b = y - ax = p_z/p_s - a p_2/p_1 \quad \text{(1a)}$$

from which it is possible, using values of a contained in Table 4 and of x and y contained in Table 8, to compute a new value of b. The graphical significance of this new value is that it is the y-intercept of a line having the same slope as that derived by least-square analysis, but passing through the point representative of the annual means contained in Table 7. Table 9 contains both the new value of b thus computed and the difference between this value and the corresponding value contained in Table 5.

TABLE 9.—*Values of b for the relation y=f(x) characteristic of the annual mean.*

Station.	b_3	Diff.[1]	b_4	Diff.[1]	b_5	Diff.[1]
Ellendale	−1.0426	−0.0003	−1.3597	−0.0003	....	....
Drexel	−0.9693	.0003	−1.4272	.0003	−1.2012	0.0004
Broken Arrow	−1.0363	−.0006	....	....	....	....
Groesbeck	−1.4422	−.0008	−1.9173	−.0012	....	....
Royal Center	−1.0800	.0004	−1.3531	.0001	....	....
Mount Weather	−0.9744	.0000	−1.3020	.0004	−1.0921	−.0010
Due West	−0.9949	−.0003	−1.2426	.0001	....	....
Leesburg	−1.6986	.0001	....	....	....	....

[1] Value of b in Table 9 minus value in Table 5.

The differences are, in all cases, quite small; but since the values determined by each method have characteristic merits, it is thought that a mean of the two methods should give a value of greater reliability than either considered separately. Consequently, such a mean was formed in each case. The final values of b thus determined appear in Table 10. But before presenting them, there

is the further consideration of the correct value of a to accompany the new values of b. It is clear that if the mean value of b differs from the value determined by the second method, a line passing through the mean b will not pass exactly through the point representing the annual mean of the ratios. In order to make it do this, it would be necessary to vary a slightly. This can be done by means of the equation

$$a = \frac{y-b}{x} = p_1[(p_z/p_s) - b]/p_2 \text{ - - - - - - - - - - (1b)}$$

also derived from equation (1). Substitutions have been made in this equation, and the results, which may be regarded as the final values of a and b appear in Table 10.

TABLE 10.—*Final values of a and b for the various aerological stations.*

Station.	With respect to level—					
	3 km. above s. l.		4 km. above s. l.		5 km. above s. l.	
	a	*b*	*a*	*b*	*a*	*b*
Ellendale	2.003	−1.0424	2.263	−1.3595	.....	.....
Drexel	1.916	−0.9694	2.336	−1.4273	1.994	−1.2014
Broken Arrow	1.976	−1.0360	.....	.....	.....	.....
Groesbeck	2.424	−1.4418	2.866	−1.9167	.....	.....
Royal Center	2.025	−1.0802	2.238	−1.3531	.....	.....
Mount Weather	1.935	−0.9744	2.206	−1.3022	1.878	−1.0916
Due West	1.928	−0.9947	2.113	−1.2426	.....	.....
Leesburg	2.710	−1.6986	.....	.....	.....	.....

It is seen, when Tables 4 and 10 are compared, that there is very little difference between the values of a derived by the two methods. This indicates that the bodies of data which were treated by the method of least squares were truly representative of mean conditions.

Errors of computation attributable to errors of x.—Hitherto, in this paper, it was assumed that the values of x, i. e., p_2/p_1, were free from error. But, in practice, when use is made of pressures at these levels which are, themselves, the results of computation, it is clear that error must be introduced into the final result by the inaccuracies of the components of the value of x. The investigation of the accuracy of the method of obtaining p_1 and p_2 was referred to earlier [9] in this paper. From that investigation it is possible to obtain certain facts which will be useful here. For example:

(1) Errors in p_1 and p_2, if relatively large, were usually of the same algebraic sign.

(2) Errors of p_2 were usually about twice those of p_1.

(3) About 90 per cent of the errors of p_1 were less than 0.05 inch (1.69 mb.) and an equal percentage of errors of p_2 were less than 0.11 inch (3.73 mb.).

If p_s is considered free from error (it is probably the most precise of all meteorological measurements), and if a is regarded as subject to such small errors as are indicated by the probable errors discussed earlier (the error of b is probably negligibly small), we may derive from equation (1) the following expression from which the degree of error to be expected in p_z may be computed:

$$dp_z = p_s[(p_1 p_2 da + p_1 a dp_2 - p_2 a dp_1)/p_1^2] \text{ - - - - - - (9)}$$

Let, for example, p_s be 950 mb.; p_1, 900 mb.; p_2, 800 mb.; and let a be 2.000; da, .001; dp_1, −1.5 mb.; dp_2, −3.5 mb.; and these, when substituted in the above equation give

$$dp_z = -3.7 \text{ mb. (0.11 inch).}$$

[9] See footnote 2, p. 437.

If the above figures are again the same except for dp_1 and dp_2 which may be assumed to be small and of opposite sign, as for example, 0.5 mb., and −0.5 mb., respectively, we have,

$$dp_z = -1.1 \text{ mb. (−0.03 inch).}$$

If the algebraic signs of these errors are reversed,

$$dp_z = 2.7 \text{ mb. (0.08 inch).}$$

These results are sufficient to indicate the order of magnitude of the errors to be expected in computations of p_z. It is seen at once that, *regardless of the level to which the computations refer, the accuracy is just about as satisfactory at the high level as at the 2 km. level.* This is a fact which lends considerable importance to the law of pressure ratios as an effective means of computing pressures at higher levels.

Before undertaking the task of determining the constants of the linear equations for nonaerological stations, it will be of interest to compute a few pressures for these high levels at the aerological stations, using values of p_1 and p_2 that have been computed from surface conditions alone, and to compare the results with pressures measured by means of kites at those levels. This can be done very readily by referring to kite flights made during the period December 1, 1922, to February 28, 1923, during which time these free-air reductions were performed by a group of stations in the central and eastern United States in connection with a test of the efficacy of the method of computation. The Aerological Division has supplied the data, and Table 11 contains the comparisons and residual errors.

TABLE 11.—*Comparison for various aerological stations of pressures observed by means of kites, and pressures computed by the law of pressure ratios, employing computed pressures at 1 and 2 kilometers above sea level.*

Station.	Date.	Pressure at—							
		3-kilometer level.				4-kilometer level.			
		Observed (mb.).	Computed (mb.).	Difference.		Observed (mb.).	Computed (mb.).	Difference.	
				Mb.	In.			Mb.	In.
	1922.								
Ellendale, N. Dak.	Dec. 1	693.4	691.8	+1.6	+0.05	608.0	605.6	+2.4	+0.07
	1923.								
	Jan. 7	685.7	686.9	−1.2	− .03	601.6	602.2	−0.6	− .02
	Jan. 12	697.7	697.7	0.0	.00	613.4	611.5	+1.9	+ .06
	Jan. 17	694.3	696.0	−1.7	− .05	611.4	614.5	−3.1	− .09
	Feb. 24	695.0	698.2	−3.2	− .10	609.9	613.6	−3.7	− .11
	Feb. 25	691.0	691.0	0.0	.00	607.2	605.3	+1.9	+ .06
	1922.								
Drexel, Nebr.	Dec. 22	698.7	698.1	+0.6	+ .02	616.1	615.2	+0.9	+ .03
	Dec. 25	697.1	698.7	−1.6	− .05	614.5	615.8	−1.3	− .04
	Dec. 28	699.6	702.1	−2.5	− .07	614.9	618.2	−3.3	− .10
	1923.								
	Jan. 25	698.1	696.3	+1.8	+ .05	614.5	611.7	+2.8	+ .08
	Feb. 5	702.7	701.1	+1.6	+ .05	618.2	615.0	+3.2	+ .10
	1922.								
Broken Arrow, Okla.	Dec. 19	708.7	709.5	−0.8	− .02	.....	.....	.....	.....
	Dec. 21	705.4	707.1	−1.7	− .05	.....	.....	.....	.....
	1923.								
	Jan. 11	699.2	703.3	−4.1	− .12	.....	.....	.....	.....
	Jan. 19	710.7	713.5	−2.8	− .08	.....	.....	.....	.....
	1922.								
Groesbeck, Tex.	Dec. 6	715.8	715.3	+0.5	+ .01	633.4	632.6	+0.8	+ .02
	Dec. 31	701.5	701.5	0.0	.00	617.6	617.5	+0.1	.00
	1923.								
	Jan. 23	701.6	704.9	−3.3	− .10	616.0	622.4	−6.4	− .19
	Feb. 28	704.0	709.4	−5.4	− .16	619.0	625.4	−6.4	− .19
	1922.								
Royal Center, Ind.	Dec. 24	699.1	699.9	−0.8	− .02	614.9	613.5	+1.4	+ .04
	1923.								
Due West, S. C.	Jan. 22	709.0	712.1	−3.1	− .10	625.1	628.7	−3.6	− .11

This table is self-explanatory and calls for very little comment. The number of cases is so small that no attempt will be made to treat the residuals statistically. The object is rather to show the general magnitude of the departures of the computed pressures from the observed. This, it will be seen, is about the same as for the 2-kilometer level, even at the 4-kilometer level. The reader, if he is familiar with the discussion of the accuracy of the 1 and 2 kilometer maps, will recall that one of the difficulties of using aerological stations in combination with nonaerological stations for making the isobaric maps was that the surface temperature at the former was often too low relatively owing to the exposure of thermometers so near the ground. This had its reflection in pressures at 1 and 2 kilometers that were likewise low. In a like manner, pressures at these two levels, which are themselves too low, will produce similar results in the pressure at 3 or 4 kilometers. It is gratifying to note, however, that, even in cases where the error at 1 and 2 kilometers was rather large, the error at the high levels was not any greater than that at 2 kilometers. This indicates that if we accept the 2-kilometer map as correctly indicative of barometric conditions at that level, we must also accept the 4-kilometer chart, for it is possessed of no greater error.

THE DETERMINATION OF CONSTANTS FOR NONAEROLOGICAL STATIONS.

The constant a.—It was learned from equation (5) that the value of dy/dx, or a, is a function of the mean temperatures of the two air columns, one extending from the surface to the highest level under consideration, and the other from the 1 to the 2 kilometer level, when Z_z is regarded as a parameter. It is obvious that one means of approaching the problem of the determination of a for interlying nonaerological stations is to determine for each aerological station and each level the numerical value of the differential coefficient $d\theta_z/d\theta_{1-2}$. This value could then be reduced to correspond to air columns of uniform length at the various stations, which would eliminate the factor Z_z and leave the differential term subject to temperature alone, which is a variable having a marked geographic distribution. Thus the values of $d\theta_z/d\theta_{1-2}$ could be plotted geographically and interpolations made for the nonaerological stations. Thence by a process which is the reverse of that mentioned above for obtaining values corresponding to uniform lengths of air column, the value could be determined for the length of air column characteristic of each station. Finally, by the substitution of proper values for the temperatures, the value of dy/dx for nonaerological stations could be computed. Such a process, while it possesses the merit of permitting a to be *computed*, is indirect. There is a shorter method which is, however, akin to that sketched above.

This second plan is to deal directly with the values contained in Table 10. As was stated above, these values are dependent upon several factors—the mean temperatures of two air columns, and the lengths of two air columns. The temperature terms have a geographical distribution, but the length of the long air column Z_z is characteristic of each station. In order to make the values of a, empirically derived, as was shown above, comparable with one another, one must first eliminate the effect of the different characteristic values of Z_z at the various stations. This may be done graphically.

If one plots the value of a as an ordinate, and the value of Z_z as an abcissa, one obtains a curve showing the relation between these two factors. When such a curve is plotted for each aerological station, it is possible to take from the graph a value of a which would correspond to any desired length of air column at any station. Thus, for each station, have been taken from the curves in Figure 5, a series of values of a between 2,750 and 4,000 meters. This gives, for a given length of air column, values of a for each station corresponding to exactly the same length of air column. In other words, the values of a are those which would have come from the least square analysis had a uniform length of air column been used at each station instead of certain levels above sea level. In Figure 5, the values of a are given on the left-hand scale of ordinates; the corresponding angle of inclination of the straight line appears on the right-hand scale of ordinates. The scale at the bottom of the figure shows the length of air column in meters, and at the top in feet.

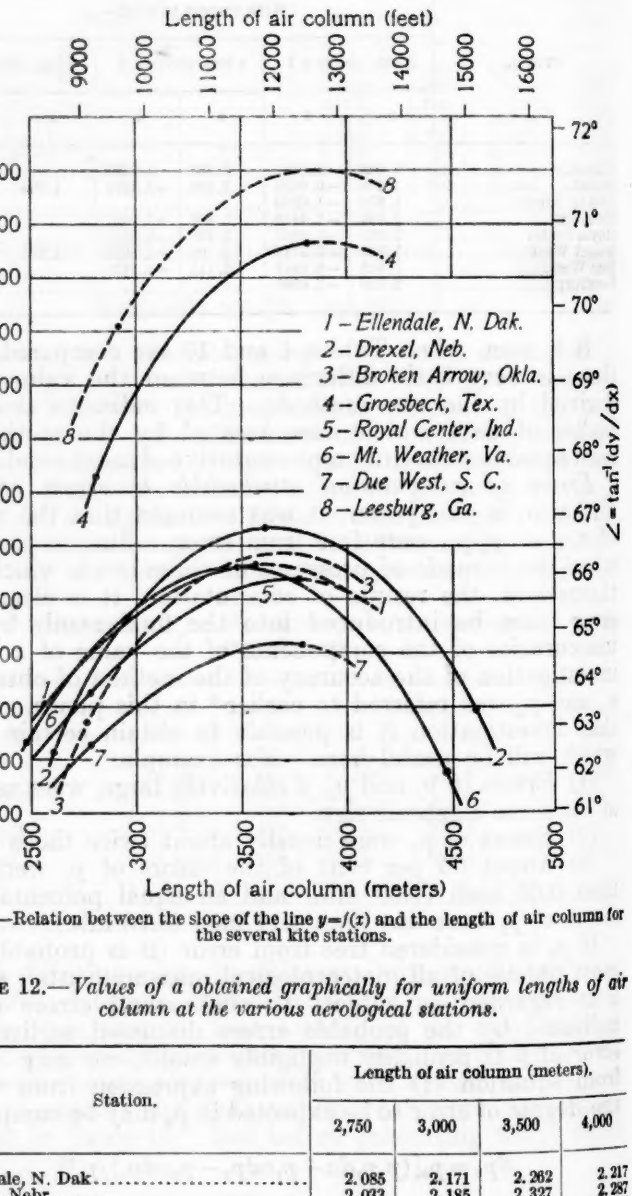

FIG. 5.—Relation between the slope of the line $y=f(x)$ and the length of air column for the several kite stations.

TABLE 12.—*Values of a obtained graphically for uniform lengths of air column at the various aerological stations.*

Station.	Length of air column (meters).			
	2,750	3,000	3,500	4,000
Ellendale, N. Dak	2.085	2.171	2.262	2.217
Drexel, Nebr	2.033	2.185	2.327	2.287
Broken Arrow, Okla	1.960	2.120	2.275	2.247
Groesbeck, Tex	2.358	2.581	2.813	2.861
Royal Center, Ind	2.015	2.106	2.220	2.214
Mount Weather, Va	2.086	2.184	2.260	2.160
Due West, S. C	1.915	2.001	2.105	2.084
Leesburg, Ga	2.583	2.760	2.961	2.995

These data, being subject only to geographical variation, may be plotted upon maps and lines of equal value

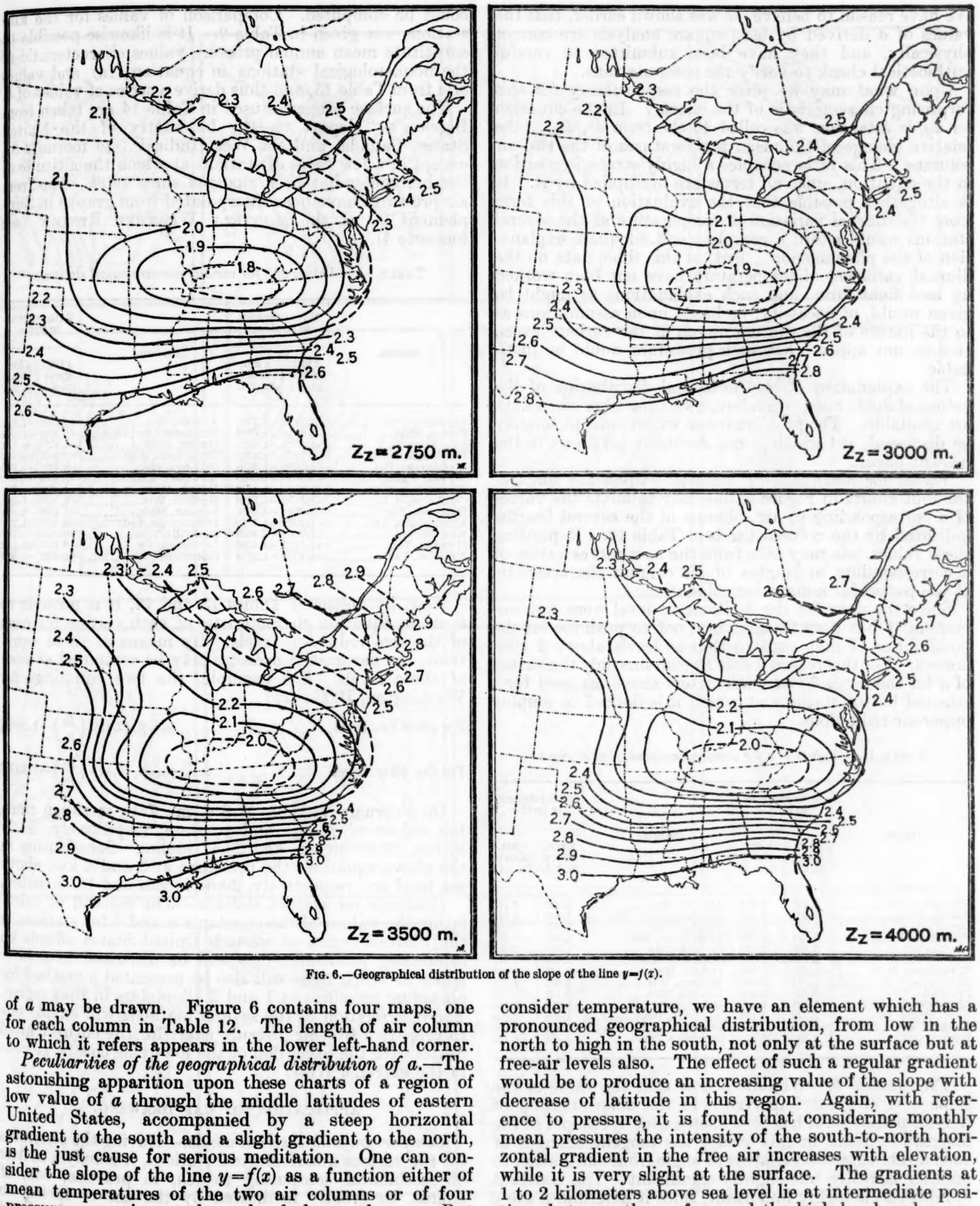

FIG. 6.—Geographical distribution of the slope of the line $y=f(x)$.

of a may be drawn. Figure 6 contains four maps, one for each column in Table 12. The length of air column to which it refers appears in the lower left-hand corner.

Peculiarities of the geographical distribution of a.—The astonishing apparition upon these charts of a region of low value of a through the middle latitudes of eastern United States, accompanied by a steep horizontal gradient to the south and a slight gradient to the north, is the just cause for serious meditation. One can consider the slope of the line $y=f(x)$ as a function either of mean temperatures of the two air columns or of four pressures occurring at the ends of these columns. But however one may look at it, there is difficulty in seeing why dy/dx should, as one progresses from north to south, first decrease slowly and finally increase rapidly. If we consider temperature, we have an element which has a pronounced geographical distribution, from low in the north to high in the south, not only at the surface but at free-air levels also. The effect of such a regular gradient would be to produce an increasing value of the slope with decrease of latitude in this region. Again, with reference to pressure, it is found that considering monthly mean pressures the intensity of the south-to-north horizontal gradient in the free air increases with elevation, while it is very slight at the surface. The gradients at 1 to 2 kilometers above sea level lie at intermediate positions between the surface and the high level under consideration. Consequently, when ratios are formed they also increase regularly from north to south and the result is the same as under the consideration of temperature.

We have reason to believe, as was shown earlier, that the values of a derived by least-square analysis are correct physically, and they have been submitted to careful arithmetical check to verify the computations.

Upon what may we place the responsibility for this surprising characteristic of the charts? In the equation for dy/dx attention was called to the term $d\theta_x/d\theta_{m-n}$, the relative change of the mean temperatures of the two air columns. This ratio occupies a highly strategic position in the equation, since all terms are multiplied by it. It is altogether possible that the evaluation of this term from the diurnal variation of temperature at the several stations would afford a complete and adequate explanation of the phenomenon. But, at this time, data on the diurnal variation of temperature have not been worked up into final form, and such explanations as might be given would, of necessity, be based upon assumptions as to the nature of the diurnal march at the various levels. It does not appear that such procedure would be justifiable.

The explanation of the horizontal distribution of the values of dy/dx must, therefore, await the time when data are available. The problem is one which must ultimately be discussed, yet which is not decidedly pertinent to the present paper.

Values for nonaerological stations.—Upon the basis of the four charts in Figure 6, one may tabulate the values of a corresponding to air columns of the several lengths indicated by the column heads in Table 12. Replotting these values, one may take from the new curves values of a corresponding to lengths of air column characteristic of the particular nonaerological station.

Since the data for the 5-kilometer level were not numerous, it has been thought best not to push too far the possibilities of map construction at levels above 4 kilometers. For this reason Table 13 contains only the values of a for the levels 3 and 4 kilometers above sea level for a selected list of stations at which it is desired to employ upper-air reductions.

TABLE 13.—*Values of a for various nonaerological stations.*

Station.	With reference to level—		Station.	With reference to level—	
	3 km. above m. s. l.	4 km. above m. s. l.		3 km. above m. s. l.	4 km. above m. s. l.
Burlington, Vt	2.535	2.684	Abilene, Tex	2.000	2.778
Boston, Mass	2.563	2.581	Oklahoma City, Okla	1.945	2.517
New York, N. Y	2.351	2.462	Omaha, Nebr	1.957	2.321
Pittsburgh, Pa	2.081	2.260	Little Rock, Ark	2.091	2.337
Washington, D. C	2.190	2.199	St. Louis, Mo	1.919	2.051
Norfolk, Va	2.260	2.213	Moorhead, Minn	2.076	2.247
Wilmington, N. C	2.291	2.294	Duluth, Minn	2.128	2.340
Charleston, S. C	2.534	2.628	Madison, Wis	2.090	2.276
Pensacola, Fla	2.789	3.008	Lansing, Mich	2.145	2.370
Birmingham, Ala	2.201	2.472	Indianapolis, Ind	1.905	2.110
New Orleans, La	2.779	3.008	Nashville, Tenn	1.795	1.949
Houston, Tex	2.674	2.981	Lexington, Ky	1.842	2.005
Palestine, Tex	2.438	2.840	Columbus, Ohio	1.961	2.185

The constant b.—While it is true that the value of the slope a is of great importance in the determination of free-air pressures, it has been shown that, for slopes of the magnitude found in this study, the tangent changes at such a rate that the variation of angle from one station to another is really but slightly significant. The constant b, however, is highly important, since it determines the y intercept. Its variation produces significant vertical displacements of the line $y=f(x)$.

It was shown that by the use of equation (1a) and mean annual pressure values very accurate values of b could be computed. Comparison of values for the kite stations was given in Table 9. It is likewise possible to substitute mean annual pressure values characteristic of the nonaerological stations in equation (1a) and values of a from Table 13, and thus derive a series of values of b.

The surface pressures used in Table 14 are taken from Bigelow's "Report on the barometry of the United States, Canada, and the West Indies" (see footnote 8), except in a few cases of stations at which the altitude of the barometer has been changed since 1900. The free-air pressures have been interpolated from graphs in Supplement 20 of the MONTHLY WEATHER REVIEW (see footnote 4).

TABLE 14.—*Values of b for various nonaerological stations.*

Station.	With reference to level—		Station.	With reference to level—	
	3 km. above m. s. l.	4 km. above m. s. l.		3 km. above m. s. l.	4 km. above m. s. l.
Burlington, Vt	−1.5436	−1.7591	Abilene, Tex	−1.0301	−1.8071
Boston, Mass	−1.5714	−1.6706	Oklahoma City, Okla	−0.9967	−1.5885
New York, N. Y	−1.3803	−1.5621	Omaha, Nebr	−1.0111	−1.4190
Pittsburgh, Pa	−1.1277	−1.3711	Little Rock, Ark	−1.1477	−1.4482
Washington, D. C	−1.2428	−1.3334	St. Louis, Mo	−0.9911	−1.1905
Norfolk, Va	−1.3050	−1.3455	Moorhead, Minn	−1.1202	−1.3572
Wilmington, N. C	−1.3323	−1.4170	Duluth, Minn	−1.1608	−1.4346
Charleston, S. C	−1.5476	−1.7119	Madison, Wis	−1.1326	−1.3819
Pensacola, Fla	−1.7744	−2.0501	Lansing, Mich	−1.1836	−1.4675
Birmingham, Ala	−1.2372	−1.5610	Indianapolis, Ind	−0.9718	−1.2383
New Orleans, La	−1.7658	−2.0508	Nashville, Tenn	−0.8810	−1.1006
Houston, Tex	−1.6702	−2.0245	Lexington, Ky	−0.9127	−1.1420
Palestine, Tex	−1.4520	−1.8914	Columbus, Ohio	−1.0226	−1.3053

Now, by means of Tables 13 and 14, it is possible to form an equation characteristic of each station for each of the two reduction levels. By means of these equations, the barometric pressure may be computed at each of these levels. For example, the two equations for Washington, D. C., are:

For the 3-km. level .... $p_3=p_s\left[2.190\left(\frac{p_2}{p_1}\right)-1.2428\right]$

For the 4-km. level .... $p_4=p_s\left[2.199\left(\frac{p_2}{p_1}\right)-1.3334\right]$

On February 7, 1923, at 8 a. m., 75th meridian time, the values of p_s, p_1, and p_2 were, respectively, 30.21 inches, 26.67 inches, and 23.47 inches. Substituting in the above equations the pressures at 3 and 4 km. above sea level are, respectively, 20.68 inches and 18.18 inches.

Constants for plateau stations.—The method of calculating the values of the constants a and b for stations in the Plateau region of western United States affords an interesting problem. This will be discussed in a later paper in which there will also be presented a method for obtaining pressures at 1 and 2 kilometers in that region. The combination of the several methods will enable one to prepare a free-air pressure chart for the entire United States with the exception of the low-lying coastal regions in the extreme West.

APPLICATION TO MAP DRAWING.

Comparison with observed winds.—Having the constants for the various nonaerological stations, it is only a matter of mechanical computing (which, in practice, can, of course, be greatly facilitated by the use of tables) to obtain pressures at 3 and 4 kilometers above sea level and draw isobaric charts. To facilitate the preparation of a few test charts, the Aerological Division has supplied free-air wind data obtained by means of pilot balloons for

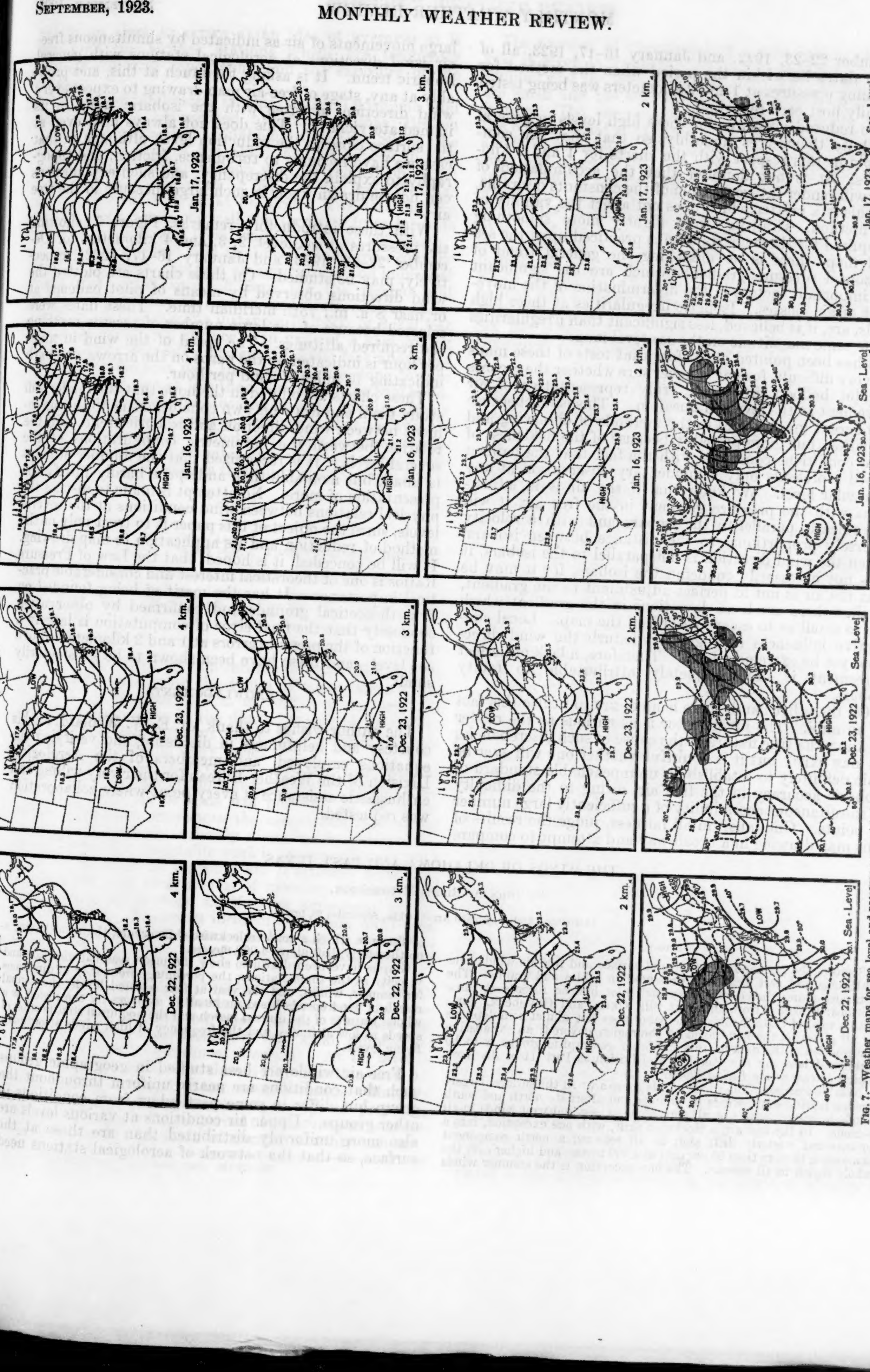

FIG. 7.—Weather maps for sea level and pressure maps at 2, 3, and 4 kilometers above sea level for December 22–23, 1922, and January 16–17, 1923. Wind arrows on free-air maps indicate the winds observed at aerological stations, each barb indicating a velocity of 10 miles per hour. Shaded areas on sea level charts indicate precipitation occurring during the 24 hours *preceding* time of the map.

December 22–23, 1922, and January 16–17, 1923, all of which dates lie within the period when the method for obtaining pressures at 1 and 2 kilometers was being tested by daily post card reporting.

The reduced pressures for these high levels in general distribute themselves smoothly, so that they are comparable in this respect with the charts for 1 and 2 kilometers. It is not doubted that the accumulation of data will render future revision of the constants desirable, but this is a matter which does not affect the validity of the method. Granting that slightly more smoothing is required for these charts than is practiced upon the sea level map, there is no mistaking the general trend of horizontal pressure gradients which are the significant and important factors in the determination of the movement of air masses. Isobaric irregularities at these high levels, are, it is believed, less significant than irregularities of the same magnitude on the sea level map.

It has been pointed out before that tests of these maps are very difficult, for one is never sure whether the records of pilot balloon flights are truly representative of air movement at the levels in question. This is not because of inherent inaccuracies in the methods of observing and reduction, but more probably because of the fickleness of wind conditions combined with the fact that the balloon record represents only a momentary observation at any particular level. We know that if the air is in adjustment with the pressure gradient in the free air, it will move nearly parallel to the isobars and with a velocity inversely proportional to the distance between isobars. When the wind direction is not parallel to the isobars, it does not necessarily condemn the isobars, for it may be that the air is not in perfect adjustment to the gradient, or that there are local deviations in the gradient which are so small as to escape record on the map. Local convective influences may greatly disturb the wind direction, yet be extremely local. Therefore, a lack of perfect agreement is not completely attributable to faulty isobars.

On the other hand, there is no desire to utilize this fact as an alibi. The investigator is as curious as the reader to know the true nature of the cause of such discrepancies as may exist; but it is doubtful whether one will ever be able definitely to establish an unimpeachable standard of isobaric accuracy in the free air, owing to the difficulty of simultaneous accessibility of a sufficiently large number of points. One must, in all fairness, judge the results of this map drawing in a broad way and attempt to compare large movements of air as indicated by simultaneous free-air wind directions at aerological stations with general isobaric trend. It is asking too much at this, and probably at any, stage of free-air map drawing to expect every wind direction to agree with the isobaric trend in its immediate vicinity. This does not always hold even at the surface close to the reduction level, although in that case we have recourse to turbulence, friction, and topography to explain the discrepancy; and such explanations can not be drawn upon in such large measure in the free air.

With these introductory remarks, Figure 7, showing the pressures at sea level, 2, 3, and 4 kilometers for December 22–23, 1923, and January 16–17, 1922, respectively, may be studied. On these charts are plotted the wind directions observed by means of pilot balloons at or near 8 a. m., 75th meridian time. These dates were selected because of the large number of ascents reaching the required altitudes. The speed of the wind in miles per hour is indicated by the barbs on the arrows, one barb indicating 10 miles of wind per hour.

These charts are offered in the hope that the reader will study them and draw his own conclusions as to the agreement between wind direction and isobaric trend, and the relation between the barometric configurations at the several levels. It is recognized that the number of maps is small, but available time and space hardly justify the presentation of more. No attempt is made to discuss the physical relations between wind conditions at the several levels, since the object of this paper is to treat only of the method of reduction and its application to map drawing. It will be conceded, it is hoped, that the Law of Pressure Ratios is one of theoretical interest and considerable practical importance. It has the merit of being founded on firm theoretical grounds and confirmed by observation so closely that the final error of computation is largely a function of the pressure errors at 1 and 2 kilometers above sea level—and these have been shown to be satisfactorily small.

ACKNOWLEDGMENTS.

The author wishes to thank Mr. E. W. Woolard, for his courtesy and helpfulness in discussing and verifying the equations employed, and members of the Aerological Division of the Weather Bureau for their very willing and enthusiastic assistance at every point where collaboration was requested.

THE WINDS OF OKLAHOMA AND EAST TEXAS.

By JOHN A. RILEY, Meteorologist.

[Aerological Station, Broken Arrow, Okla., September 26, 1923.]

SYNOPSIS.

Some of the outstanding features of surface and free-air winds over Oklahoma and east Teaxs are presented in tables and graphs. The data are mainly based on four years' pilot balloon records at three stations: Broken Arrow and Fort Sill, Okla., and Groesbeck, Tex., with a total of 7,075 flights. The paper does not aim at completeness for all phases of the wind even for the region covered; an exhaustive compilation of the data for this and other geographic groups is to be published later by the Aerological Division as Part II of *An Aerological Survey of the United States.*

Notable features of the winds of this group are: At the surface, largely predominating south winds in summer and alternate north and south winds in winter, with a small percentage of east and west winds in all seasons. In the free air, a clockwise shift, with one exception, into a pronounced westerly drift aloft in all seasons; a north component amounting to more than 50 per cent at 4,000 meters and higher over the whole region in all seasons. The one exception is the summer winds of Texas in which a counterclockwise shift occurs, the wind having a northeasterly drift above 4,000 meters.

Graphs have been drawn to show the mean seasonal direction and velocity at the three stations; the percentage frequency of directions for summer, winter, and the year at four selected levels; the annual march of wind speeds based on monthly averages for the region as a whole; features of the diurnal march and the nocturnal stratification of speeds at low altitudes; and the frequency of high winds at ordinary flying levels.

Free-air winds are best studied in geographic groups such that conditions are nearly uniform throughout the group but differ in some particulars from conditions in other groups. Upper air conditions at various levels are also more uniformly distributed than are those at the surface, so that the network of aerological stations need

not be so close to arrive at an idea of averages as is necessary for surface stations which are frequently affected by local topography and the exposure of the station.

The region embraced in this study—Oklahoma and east Texas—is represented by three stations: Broken Arrow in northeastern Oklahoma and Fort Sill in the southwestern part of the State, and Groesbeck in east central Texas. Pilot balloon work is carried on at all three stations; kite work is done at the two Weather Bureau stations but not at Fort Sill. The data may be said to represent fairly well the territory from latitude 31° to 37° north and from longitude 95° to 99° west.

Most of this region is in the once famous grass country of the Southwest; it is now an agricultural and industrial district of importance. Except for the rugged and forested mountains of eastern and south-central Oklahoma which rise in some instances to 2,500 or 3,000 feet above sea level, the surface is in general a vast rolling plain. From the lofty plateau of 2,000 feet above sea level in the western part there is a gentle slope toward the south and east to less than 500 feet in the southeast.

The three stations are located in open country, freely exposed to winds from all directions, so that the records at lower levels are not affected by unusual topography. The geographical coordinates and elevation of each station and the record used in this study are given in Table 1.

TABLE 1.

Station.	Altitude, m. s. l.	Latitude, N.	Longitude, W.	Period of observations (inclusive).	
	Meters.	° ′	° ′	From—	To—
Broken Arrow, Okla..	233	36 02	95 49	November, 1918...	October, 1922.
Fort Sill, Okla.......	355	34 40	98 25	July, 1918........	June, 1922.
Groesbeck, Tex.......	141	31 30	96 28	November, 1918...	October, 1922.

Four years' pilot balloon records for each station have been used in preparing the tables of mean values. The balloons are released at 7 a. m. and 3 p. m., near the time of the extremes in the diurnal march of the winds, and the combined means therefore represent a close approach to the true daily mean.

Single-theodolite observations are the rule, but at the Weather Bureau stations two-theodolite observations are made as often as time will permit. In the lower levels on summer afternoons the ascensional rate of the balloon is sometimes seriously disturbed by convection; at such times two-theodolite work is necessary for accurate results. Vertical air currents are practically absent in the morning and comparisons of morning kite and balloon records show very satisfactory agreement in the two methods. The errors incident to certain individual observations compensate one another and in the means based on a large number of observations are nearly if not entirely eliminated.

A two-year summary, previously prepared for Broken Arrow and Fort Sill,[1] affords a comparison of the two-year with the present four-year means. The seasonal means for the two periods show very small differences; the annual means are almost identical. At no level is there a greater difference than 4° in direction and 0.7 m. p. s. in velocity in the annual means. Monthly values have not been considered, except in preparing Figure 4, because a longer period of observations is necessary for the determination of normal monthly values.

[1] Mo. WEATHER REV., November, 1920. 48: 627-632.

The number of observations for each season and the year is given in Table 5. The largest number occurs in summer and the least in winter, although the differences are small and the seasonal distribution is entirely satisfactory. The percentage of observations made during the entire period is 87 at Broken Arrow, 72 at Fort Sill, and 83 at Groesbeck. The percentage of days on which at least one observation was made is considerably higher and therefore agrees well with percentage of days on which kite flights are made. With increasing altitude above 3,000 meters the percentage of balloon observations over those made with kites rapidly increases, especially in summer, and at 5,000 meters and higher balloons furnish the only means at present used for observing the winds regularly. At Broken Arrow 43 per cent of all balloon observations reach 4,000 meters; 20 per cent at Fort Sill and 38 per cent at Groesbeck reach this level. Six per cent of all observations at Broken Arrow and Groesbeck reach the 10-kilometer level.

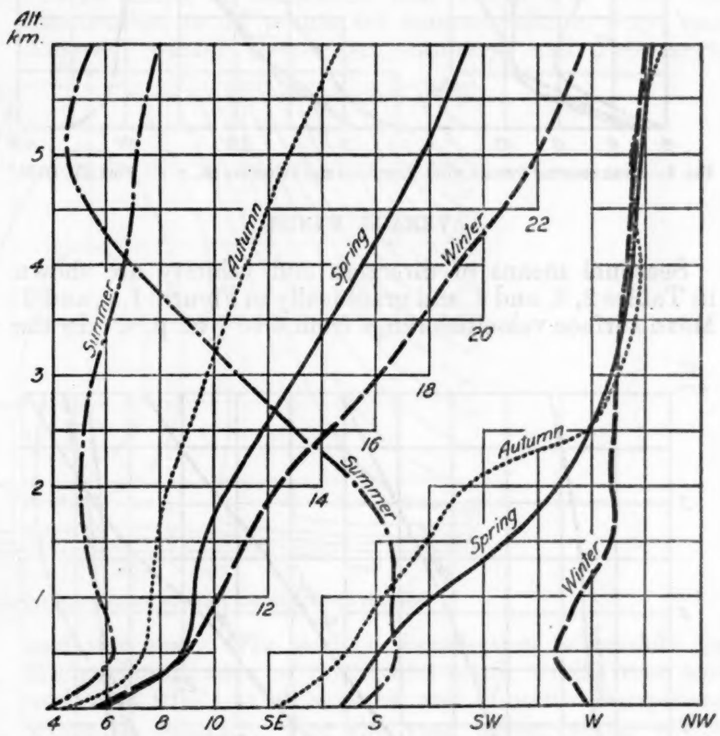

FIG. 1.—Mean seasonal free-air wind directions and velocities (m. p. s.), Broken Arrow Okla.

Disappearances of balloons are due mostly to clouds and secondly to distance. But while lower clouds seriously interfere with the work at times, the data obtained by this method are not limited to fair weather. Observations are often obtained between showers or through temporary breaks in the clouds; in fact they can be made near thunderstorms when it would be dangerous to send up kites. So that nearly all conditions are represented except storm centers where rain and low clouds are general.

Mean velocities, as in other free-air studies of this kind, have been determined by applying to the mean velocities the gradient from each level to the next higher level, thus eliminating the discontinuities resulting from fewer observations at the higher levels. Mean directions are found by resolving each direction into its north and west components and determining the mean trigonometrically. This is different from getting the prevailing direction as recorded at the regular stations, which is the direction occurring the greatest number of

times regardless of the distribution and frequency of the other directions. The surface directions in winter, as shown in Figure 5, afford a good example of this difference. Prevailing directions would be either north or south, but when the components of all directions are considered a westerly drift is found.

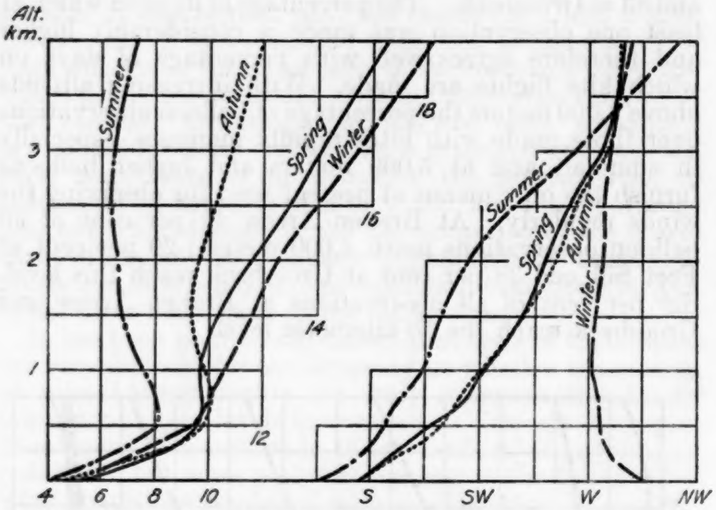

FIG. 2.—Mean seasonal free-air wind directions and velocities (m. p. s.), Fort Sill, Okla.

AVERAGE WINDS.

Seasonal means of direction and velocity are shown in Tables 2, 3, and 4, and graphically in Figures 1, 2, and 3. Mean surface velocities range from 4 to 7 m. p. s. In the

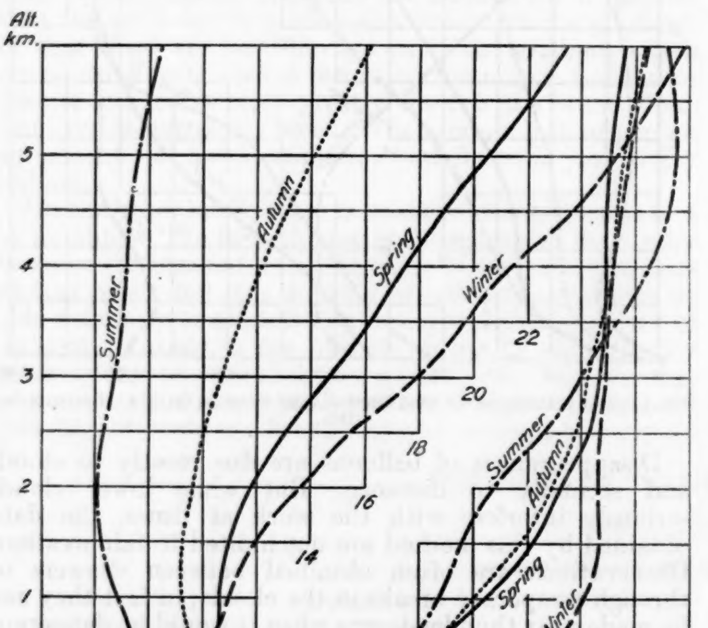

FIG. 3.—Mean seasonal free-air wind directions and velocities (m. p. s.), Groesbeck, Tex.

free air three regions may be distinguished: (1) A region of rapid increase in velocity to approximately 500 meters; (2) slight increase or even a decrease throughout the next kilometer, varying in amount and depth with the season; and (3) a region of steady increase in velocity. Light winds prevail at all altitudes in summer, the lightest free-air winds occurring at a height of 2,000 meters. Autumn wind speeds of this region, unlike those of more northerly stations, are considerably less than those of spring; an almost uniform increase in speed occurs in the upper levels from summer through autumn, spring, and winter.

TABLE 2.—*Mean free-air winds at Broken Arrow, Okla.*

Altitude (meters).	Spring.		Summer.		Autumn.		Winter.		Annual.	
	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).
	°		°		°		°		°	
Surface	S. 6 E.	6.6	S. 16 E.	4.5	S. 15 E.	5.6	S. 50 W.	6.3	S. 7 E.	5.8
250	S. 8 W.	9.1	S. 5 W.	6.8	S. 8 W.	8.4	S. 69 W.	8.4	S. 14 W.	8.2
500	S. 22 W.	10.4	S. 14 W.	7.5	S. 23 W.	9.5	S. 76 W.	9.7	S. 28 W.	9.3
750	S. 37 W.	10.6	S. 23 W.	7.2	S. 35 W.	9.4	S. 85 W.	10.5	S. 41 W.	9.4
1,000	S. 50 W.	10.6	S. 31 W.	6.8	S. 45 W.	9.2	N. 88 W.	11.0	S. 51 W.	9.4
1,500	S. 69 W.	11.0	S. 41 W.	6.3	S. 65 W.	9.2	N. 82 W.	11.9	S. 68 W.	9.6
2,000	S. 80 W.	11.8	S. 53 W.	6.1	S. 78 W.	9.7	N. 83 W.	13.6	S. 79 W.	10.3
2,500	N. 87 W.	13.1	S. 75 W.	6.3	S. 88 W.	10.0	N. 82 W.	15.4	W.	11.2
3,000	N. 82 W.	14.7	W.	6.7	N. 88 W.	10.7	N. 80 W.	17.9	N. 84 W.	12.5
4,000	N. 79 W.	17.5	N. 61 W.	7.2	N. 77 W.	12.2	N. 77 W.	21.4	N. 74 W.	14.6
5,000	N. 78 W.	20.5	N. 50 W.	7.6	N. 72 W.	14.1	N. 69 W.	25.3	N. 66 W.	16.8
6,000	N. 71 W.	23.5	N. 55 W.	8.5	N. 64 W.	16.2	N. 62 W.	27.8	N. 62 W.	19.0

TABLE 3.—*Mean free-air winds at Fort Sill, Okla.*

Altitude (meters).	Spring.		Summer.		Autumn.		Winter.		Annual.	
	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).
	°		°		°		°		°	
Surface	S. 5 E.	5.5	S. 21 E.	4.1	S. 5 E.	4.6	N. 66 W.	5.3	S. 7 E.	4.9
250	S. 10 W.	8.2	S. 4 E.	6.6	S. 12 W.	8.1	N. 81 W.	7.5	S. 13 W.	7.6
500	S. 24 W.	9.6	S. 5 W.	8.1	S. 29 W.	9.8	N. 85 W.	9.4	S. 28 W.	9.2
750	S. 39 W.	9.8	S. 11 W.	8.0	S. 35 W.	10.1	N. 86 W.	10.0	S. 38 W.	9.5
1,000	S. 45 W.	9.7	S. 21 W.	7.6	S. 45 W.	9.8	N. 89 W.	10.6	S. 47 W.	9.4
1,500	S. 62 W.	10.3	S. 29 W.	6.8	S. 62 W.	9.3	N. 87 W.	11.6	S. 61 W.	9.5
2,000	S. 72 W.	11.5	S. 39 W.	6.6	S. 77 W.	9.6	N. 83 W.	12.4	S. 74 W.	10.0
2,500	S. 82 W.	13.0	S. 58 W.	6.3	S. 84 W.	10.0	N. 83 W.	13.9	S. 84 W.	10.8
3,000	N. 84 W.	14.1	S. 83 W.	6.5	N. 82 W.	10.8	N. 80 W.	15.5	N. 84 W.	11.7
4,000	N. 76 W.	16.6	N. 53 W.	7.4	N. 77 W.	12.0	N. 71 W.	18.2	N. 73 W.	13.5

TABLE 4.—*Mean free-air winds at Groesbeck, Tex.*

Altitude (meters).	Spring.		Summer.		Autumn.		Winter.		Annual.	
	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).	Direction.	Velocity (m./s.).
	°		°		°		°		°	
Surface	S. 15 E.	5.8	S. 7 E.	3.8	S. 43 E.	4.2	S. 89 W.	5.5	S. 10 E.	4.8
250	S. 6 E.	7.8	S. 4 W.	5.6	S. 23 E.	6.7	S. 82 W.	7.7	S. 2 W.	7.0
500	S. 1 W.	8.9	S. 8 W.	6.3	S. 11 E.	7.4	S. 76 W.	9.0	S. 10 W.	7.9
750	S. 11 W.	9.1	S. 5 W.	6.1	S. 5 E.	7.6	S. 80 W.	9.6	S. 15 W.	8.1
1,000	S. 24 W.	9.3	S. 6 W.	5.7	S. 3 W.	7.7	S. 85 W.	10.1	S. 24 W.	8.2
1,500	S. 56 W.	9.6	S. 6 W.	5.3	S. 21 W.	7.9	N. 82 W.	11.2	S. 46 W.	8.5
2,000	S. 78 W.	10.6	S. 7 E.	5.0	S. 37 W.	8.3	N. 83 W.	12.4	S. 65 W.	9.1
2,500	S. 89 W.	11.7	S. 34 E.	5.2	S. 89 W.	9.1	N. 81 W.	14.2	S. 84 W.	10.0
3,000	N. 82 W.	13.1	S. 57 E.	5.5	N. 79 W.	9.8	N. 81 W.	16.2	N. 86 W.	11.2
4,000	N. 74 W.	15.5	N. 79 E.	6.6	N. 69 W.	11.2	N. 75 W.	19.1	N. 68 W.	13.1
5,000	N. 69 W.	17.8	N. 51 E.	7.1	N. 74 W.	12.8	N. 71 W.	22.0	N. 60 W.	15.0
6,000	N. 65 W.	19.4	N. 62 E.	8.0	N. 60 W.	14.7	N. 68 W.	23.7	N. 51 W.	16.4

TABLE 5.—*Number of observations on which Tables 2, 3, and 4 are based.*

Altitude (meters).	Broken Arrow, Okla.					Fort Sill, Okla.					Groesbeck, Tex.				
	Spring.	Summer.	Autumn.	Winter.	Annual.	Spring.	Summer.	Autumn.	Winter.	Annual.	Spring.	Summer.	Autumn.	Winter.	Annual.
Surface	642	694	631	572	2,539	549	550	527	483	2,109	613	635	626	553	2,427
250	642	694	625	571	2,532	549	549	527	482	2,107	611	633	619	551	2,414
500	629	688	613	551	2,481	532	544	515	473	2,064	578	603	594	509	2,284
750	598	672	590	529	2,389	508	533	490	448	1,979	525	577	570	460	2,132
1,000	561	663	581	508	2,313	470	519	471	424	1,884	489	555	540	430	2,014
1,500	486	634	538	470	2,128	393	473	386	376	1,628	415	511	476	364	1,766
2,000	423	587	494	419	1,923	299	372	309	299	1,279	355	454	431	321	1,561
2,500	344	524	434	369	1,671	216	269	225	223	933	299	411	381	271	1,362
3,000	291	487	394	330	1,502	151	203	167	165	686	251	385	341	238	1,215
4,000	202	375	290	215	1,082	91	128	103	92	414	177	309	271	164	921
5,000	122	292	230	128	772	...	...	...	...	...	130	240	213	112	695
6,000	83	227	174	80	564	...	...	...	...	...	97	180	166	74	517

Spring and autumn direction curves are much alike except at Groesbeck where the south component is much deeper in autumn than in spring; from south or southeast at the surface the wind veers to west at 3,000 meters with little change thereafter. Winter directions average nearly west at all altitudes. Summer directions show the deepest south components and the most rapid shift in the mean direction to farthest north in the upper levels. At Broken Arrow and Fort Sill there is a clockwise shift in summer from southwest at 2,000 meters to northwest at 4,000 meters and higher levels; at Groesbeck a counterclockwise shift sets in at 1,500 meters, the wind backing from south through east at 3,700 meters to northeast at 5,000 meters. There is therefore a marked northerly drift at high altitudes over the whole region in summer, with a westerly component prevailing over Oklahoma and an easterly one over Texas.

The strong east component in the upper levels above Groesbeck in summer continuing, as will be seen later, to 10 kilometers should be of interest in connection with the observed movements of upper clouds. It is in decided contrast to conditions farther north, where cirrus clouds are rarely observed moving from the east, to find that at least in Texas in summer cirrus are likely to move from the east more frequently than from the west.

During winter this region is dominated by the prevailing westerlies and average velocities are nearly as strong as those at stations farther north; this is in agreement with the charts of free-air isobars determined from kite observations.[2] In summer the southern part is invaded by the "horse latitudes." But this subtropical control is limited to the free air as shown by the large percentage of weak easterly winds. At the surface and at lower levels the wind blows steadily from the south at all places; this circulation has a monsoon character as explained by Tannehill,[3] caused by the high temperatures of the interior.

Statistical data from other southern stations are necessary to determine more completely the free-air winds of this subtropical region and reports from regions outside the United States are needed to show the effect of the southwestern continental "heat island" on the upper planetary winds.

[2] *An aerological survey of the United States.* By W. R. Gregg. Mo. WEATHER REVIEW, SUPPLEMENT No. 20.

[3] *Some characteristics of Texas rainfall.* By I. R. Tannehill. Mo. WEATHRR REV. May 1923. See also, *Cause of the accelerated sea-breeze over Corpus Christi, Tex.* By J. P. McAuliffe, Mo. WEATHER REV., November, 1922.

Figure 4 gives in another way the annual distribution of velocities. It is based on the combined monthly values of the three stations thus giving a composite picture of the annual march of velocities over the region as a whole. The marked contrast in the strength of summer and winter winds is emphasized in this diagram. It will be observed that strong winds persist from late November to early April. A sudden decrease sets in at all levels in late April and early May; in the upper levels the decrease continues through May and June. During July and August stagnant conditions prevail to great heights and the average speed from 1,500 meters to 3,000 meters falls below 6 m. p. s. Increasing velocities set in again during September and by late November have reached winter force at all altitudes.

Frequency of winds from different directions.—Figure 5 gives the percentage frequency of directions at the surface and at 1, 3, and 4 kilometers elevation. The directions for the three stations have been plotted on outline maps of Oklahoma and Texas and show the distribution to 16 points for summer (June, July, and August), winter (December, January, and February), and the year. The surface distribution is notable for the preponderance of north and south winds over east and west winds at all seasons, and of south component winds in summer. For the year winds falling within one point of either north or south constitute 62 per cent of the total at Broken Arrow, 68 per cent at Fort Sill, and 54 per cent at Groesbeck. During summer the percentage of winds within one point of south is 52 at Broken Arrow, 49 at Fort Sill, and 42 at Groesbeck. During winter there is nearly a balance between the north and south winds.

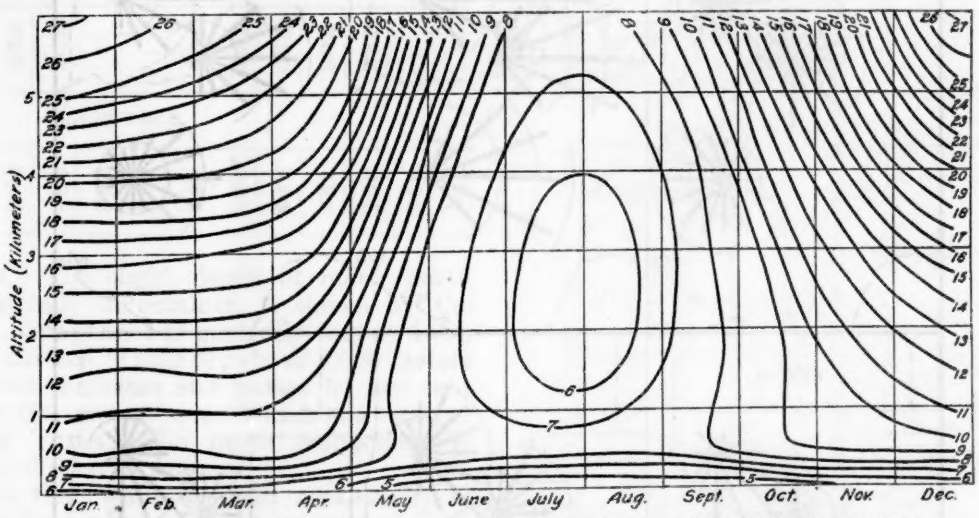

FIG. 4.—Annual distribution of velocities (m. p. s.), based on combined monthly means of three stations.

At 1,000 meters many of the directly north and south surface winds have shifted a point or two toward west; and the greatest frequency is in the southwest quadrant. At 3,000 meters and 4,000 meters winter winds are nearly all from points between southwest and northwest. Summer winds are more evenly distributed from all directions, with a prevailing westerly component at the two Oklahoma stations and an easterly component at Groesbeck.

West component.—Table 6 gives the percentage frequency of a west component and a north component for the summer and winter seasons and the year. A west component occurs in winter generally 90 per cent or more of the time above 2,000 meters. In summer there is a marked decrease in the proportion of west

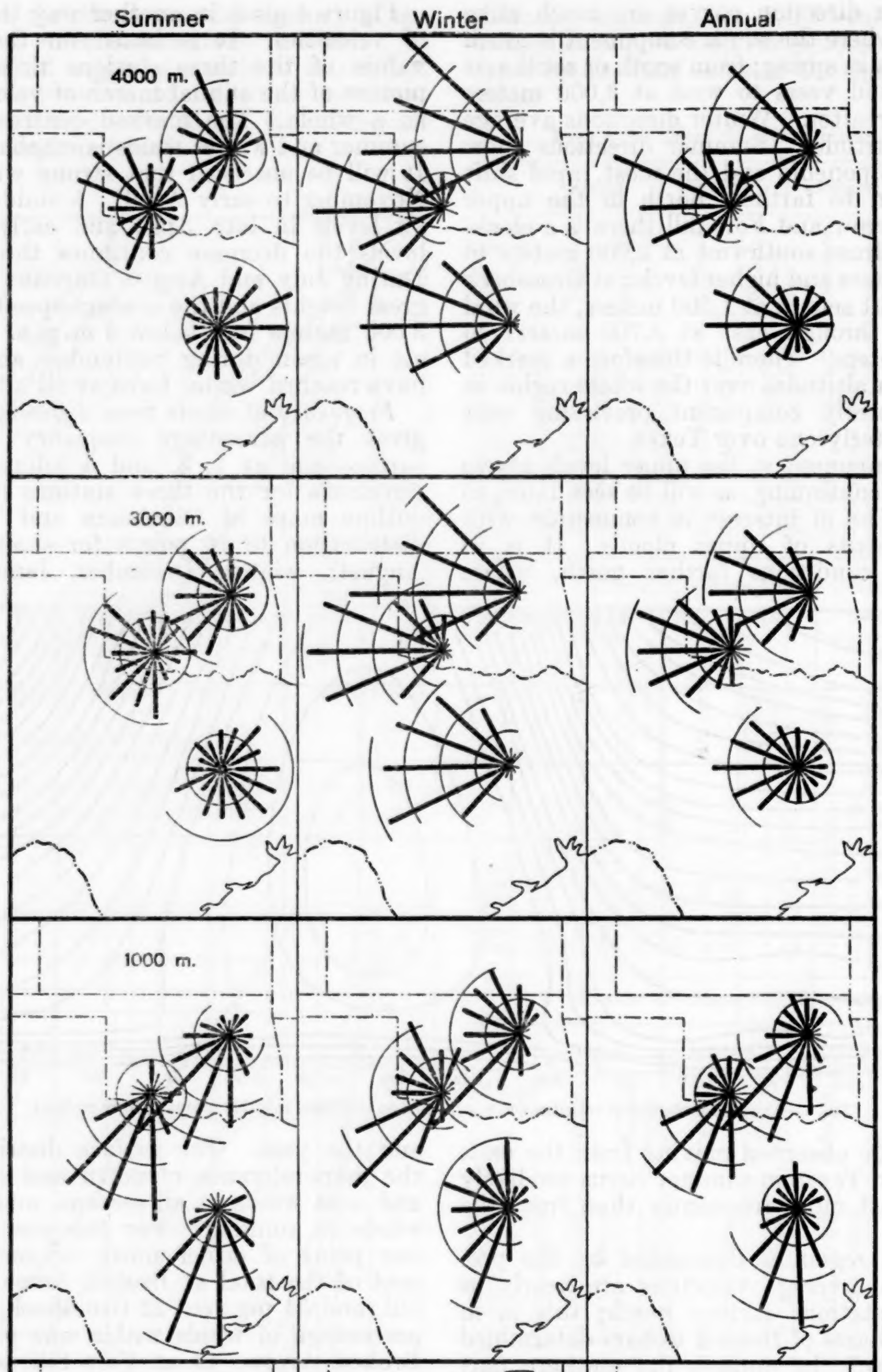

FIG. 5.—Percentage frequency of winds from different directions.

component winds with decreasing latitude, and at southern stations a steady decline of these winds with increasing altitude. At Broken Arrow in summer the percentage of west component winds is close to 70 from 1 to 6 kilometers, while at Groesbeck the percentage falls from 56 at 1 kilometer to 34 at 6 kilometers.

TABLE 6.—*Percentage frequency of a west and a north component.*

BROKEN ARROW.

	West component.							North component.						
	Altitude (kilometers).													
	0	1	2	3	4	5	6	0	1	2	3	4	5	6
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Summer..	40	67	68	68	67	71	70	28	25	37	51	58	66	64
Winter...	56	78	93	95	95	93	93	45	50	54	59	62	72	78
Year......	45	72	79	80	81	80	80	35	35	44	54	59	65	68

FORT SILL.

Summer..	38	63	66	62	61	.....	.....	27	23	33	50	59	.....	.....
Winter...	59	77	89	89	87	.....	.....	52	48	52	56	62	.....	.....
Year......	48	70	79	77	76	.....	.....	39	34	41	53	60	.....	.....

GROESBECK.

Summer..	47	56	49	42	40	39	34	20	19	34	44	54	59	59
Winter...	58	75	87	91	90	92	91	49	50	54	56	63	69	70
Year......	47	60	64	65	65	66	64	35	34	44	51	59	61	64

North component.—The slight depth of many north surface winds, especially in summer, is shown by the fact that the north component is generally less at 1,000 meters than at the surface (Table 6); above 1,000 meters the north component increases and passes 50 per cent in all seasons at 3,000 meters over Oklahoma and at 4,000 meters over Texas. The north component is greatest in winter and least in summer.

It is paradoxical that while a north component at 4,000 meters and higher is less frequent in summer than in winter the mean direction is nearer north in summer than in winter. This is explained by the fact that in winter many of the north component winds are from nearly west, i. e., west-northwest, while in summer a larger proportion of these winds are from north and north-northwest, thus bringing the mean direction around farther toward the north.

THE DIURNAL MARCH.

Diurnal changes in free-air winds as in other meteorological elements are more apparent at southern stations than at northern stations where the diurnal changes are largely obscured by the changes resulting from the more frequent passage of HIGHS and LOWS. The essential characteristics of the diurnal change are: Stronger free-air winds at night, with a pronounced apex in the velocity curve at 500 meters; and at the surface conditions just the reverse, i. e., light winds at night and strong winds in daytime. With the velocity change there also occurs a diurnal change in direction, the surface wind during the day following more closely the direction of the free-air wind at 1,000 meters.

The importance of stratification of free-air winds was brought out during the national balloon race of 1922, when it is said one of the contestants found a layer of strong velocity barely deep enough to reach from the top to the bottom of the balloon.[4] This current was effective in enabling him to win the race. While such pronounced stratification is not often observed at considerable altitudes, or at low altitudes during daytime, there is a nocturnal stratification in this region that occurs with great regularity, and is of such strength as to merit the attention of aviators. It will be particularly important in the case of night flying.

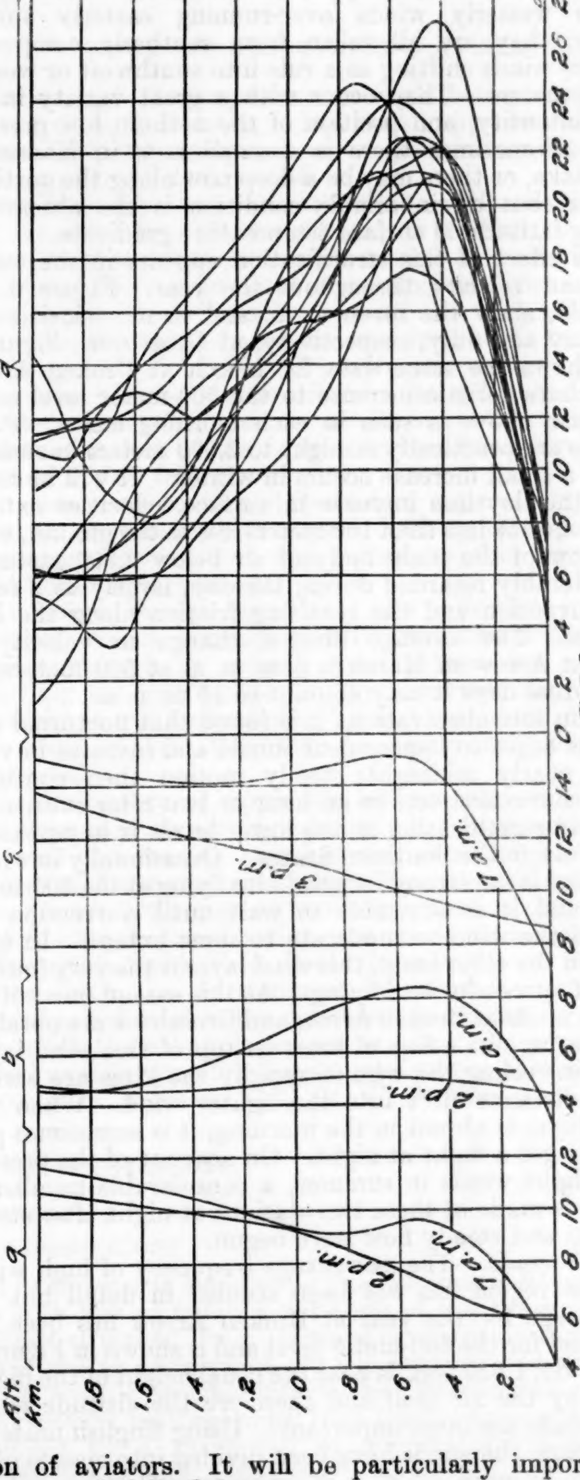

FIG. 6.—(*a*, *b*, *c*) Mean a. m. and p. m. velocity curves: (*a*) January, and (*b*) July, at Groesbeck, Tex.; (*c*) March at Broken Arrow, Okla.; (*d*) individual a. m. observations at Broken Arrow, one for each month, showing characteristic velocity increase near the 500-meter level.

This nocturnal stratification is illustrated by a set of morning velocity curves at Broken Arrow, one curve for each month of the year (fig. 6, *d*). These curves show a rapid increase of 12 to 14 m. p. s. in velocity from the surface to the 500-meter level approximately; above

this is a somewhat less rapid decrease to near the 2,000-meter level. This condition occurs at intervals throughout the year; it is infrequent in winter because the prevailingly strong winds aloft prevent the occurrence of the marked decrease in the upper part of the curves. In summer when the surface wind is from the south similar conditions may occur day after day.

None of these examples of wind stratification illustrates westerly winds over-running easterly surface winds; they are all taken from southerly component surface winds shifting as a rule into southwest or west at 2,000 meters. They occur with a great variety in the size, intensity, and position of the nothern low pressure area. Sometimes there is a small LOW in Kansas or Nebraska, or there may be a deep LOW along the northern border; but an invariable condition is the absence of strong latitudinal surface temperature gradients.

The effect of this stratification appears in the curves of mean velocity throughout the year. Figure 6, (*a*) and (*b*), show the mean a. m. and p. m. velocities for January and July, respectively, at Groesbeck; Figure 6, (*c*), shows the same data for March at Broken Arrow. The characteristic increase to the 500-meter level and a decrease above is seen in each morning curve. P. m. curves are practically straight to 2,000 meters in summer while a small increase occurs in winter. It will be noted that the daytime increase in surface velocities extends to somewhat less than 100 meters above the ground, while the flow of the main body of air below 2,000 meters is considerably retarded during the day, largely as a result of convection and the resulting friction along the land surface. The average diurnal change in velocity at Broken Arrow in March is 5 m. p. s. at 500 meters; on individual days it may amount to 15 m. p. s.

From kite observations it is found that nocturnal conditions begin to appear near sunset and increase in vigor until nearly midnight; steady motion then continues until convection sets in an hour or two after sunrise.

Wind stratification in the lower levels is important in kite work in the Southern States. Occasionally in winter the wind is too strong for good kite flying at the 500-meter level and it is advisable to wait until convection has caused the wind to moderate to some extent. In summer, on the other hand, this wind layer is the very foundation of successful kite flying. At this season most of the flights made at Broken Arrow and Groesbeck are obtained by floating out a line of kites on top of this wind layer. Then in reeling the wire in rapidly the kites are carried some distance aloft into the lighter wind. When this wind layer is absent in the morning, it is sometimes possible to get a flight at night. On account of the prevailingly light winds in summer, a considerable number of flights is made at these two stations at night after stratification and steady flow have begun.

High winds.—The percentage frequency of high winds for this region has not been studied in detail but the percentage for the year at Broken Arrow has been determined for the 500-meter level and is shown in Figure 7. This level, 1,650 feet, is near the usual height of the flights made by the air mail and therefore the altitude where high winds are most important. Using English units for this figure, the winds have been divided into classes of 30 m. p. h. or more, 40 m. p. h. or more, and 50 m. p. h. or more. A large majority of the winds in each class falls between south and southwest, the largest number being from the south-southwest. A secondary frequency in winter is from north and north-northwest but the number is small compared to the number from a southerly direction.

The annual percentage of observations in which the wind equals or exceeds 30 m. p. h. is 23; 40 m. p. h., 10; and 50 m. p. h., less than 2. As the greatest diurnal change in velocity occurs at this height, it is not surprising that 78 per cent of the winds exceeding 30 m. p. h. are observed in the morning. At the a. m. observation during the months November to April, inclusive, winds of

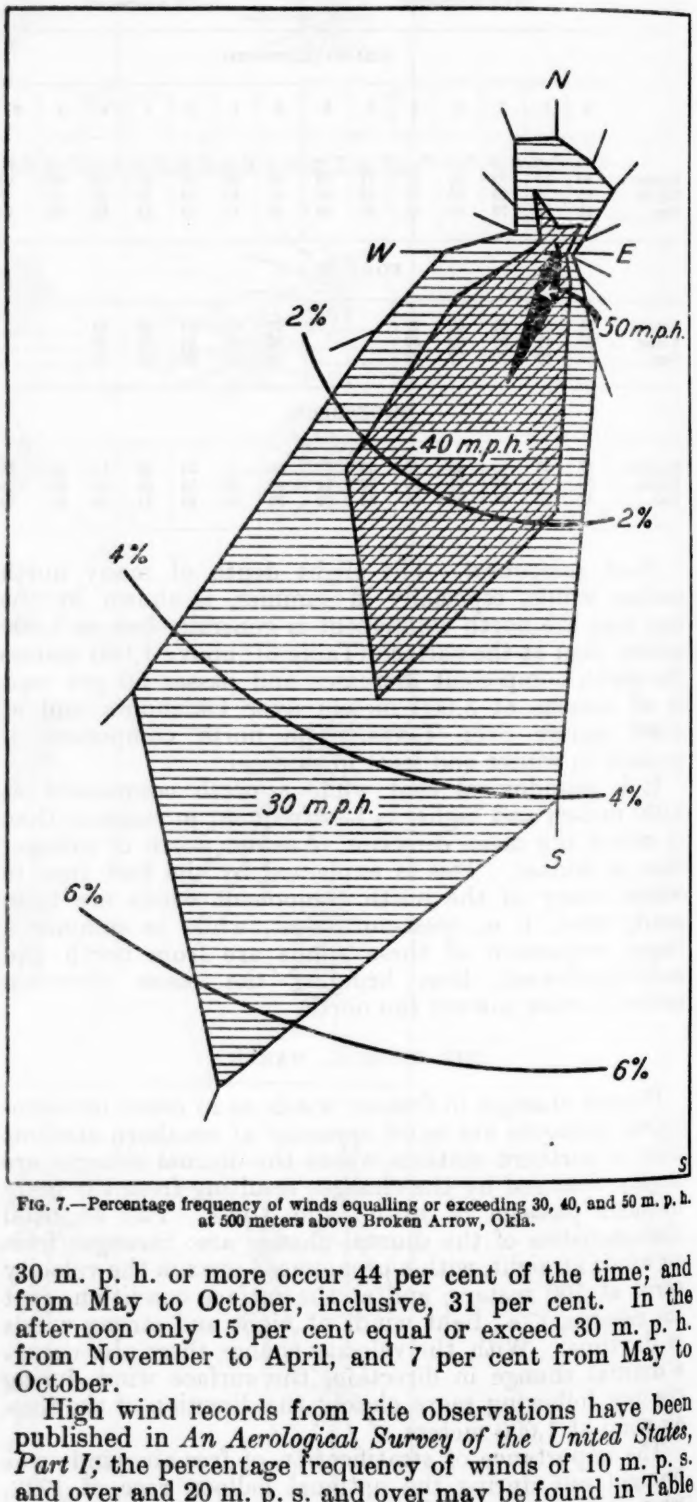

FIG. 7.—Percentage frequency of winds equalling or exceeding 30, 40, and 50 m. p. h. at 500 meters above Broken Arrow, Okla.

30 m. p. h. or more occur 44 per cent of the time; and from May to October, inclusive, 31 per cent. In the afternoon only 15 per cent equal or exceed 30 m. p. h. from November to April, and 7 per cent from May to October.

High wind records from kite observations have been published in *An Aerological Survey of the United States, Part I;* the percentage frequency of winds of 10 m. p. s. and over and 20 m. p. s. and over may be found in Table 20 of that publication; the highest winds observed are given in Table 21. Maximum winds in general are likely

[4] *The meteorological aspects of the thirteenth national balloon race, May 31, 1922.* By V. E. Jakl. MO. WEATHER REV. May, 1922. 50: 245-250.

to be somewhat higher on balloon records than on kite records for the reason that the kite flight usually follows the morning balloon observation and if a region of especially high winds is found it is likely to be avoided with the kites, or the kite flight delayed for a time.

While a knowledge of the distribution of high winds, as shown in Figure 7, will help in a general way to determine what may be expected in flying, much greater detail is desirable when applied to any particular route, as has been done by Mr. W. R. Gregg and Lieut. J. P. Van Zandt for the transcontinental air mail;[5] but such an analysis is beyond the scope of this paper. In individual cases the aviator who has a definite knowledge of existing winds gained from pilot balloon reports may often avoid strong head winds by flying above or below the customary height or by waiting until midday or later when this is possible.

Winds at high altitudes.—Winds at high altitudes are of very small importance to present day aviation; but during the last few years they have become a matter of considerable interest and speculation as affording a means of flying across the country at tremendous speed. For instance in the *Scientific American*, September, 1922, "Across America in Eight Hours," it is stated that the wind at 7½ miles up always blows from the west, "and maintains an average speed of something like 250 miles per hour."

Such statements are highly exaggerated. Pilot balloons have been sent up daily at a number of places over the United States during the past five years, and the highest velocities ever observed fall considerably short of the 250 miles per hour given as the average speed. During the winter, when the winds are strongest and blow almost continuously from a westerly direction, the average speed is about 100 to 115 miles per hour 6 miles above this region; while in summer the average speed drops to about 35 miles per hour over the southern part of the country; and winds from an easterly quarter occur with increasing frequency from the northern part of the country to the southern.

Both at Broken Arrow and Groesbeck 150 balloons have been followed to the 10-kilometer level (6.2 miles) during the 4-year period. The average speed for the year at that level at Broken Arrow is 74 miles per hour (33 m. p. s.) and at Groesbeck it is 66 miles per hour (29.4 m. p. s.). Twenty-five per cent of all winds observed at the 10-kilometer level at Broken Arrow have an easterly component, while 41 per cent at Groesbeck are easterly. In summer at Groesbeck the easterly component amounts to 66 per cent and the mean direction is northeast.

So it is not simply a matter of going up 6 or 7 miles any time and finding a gale from the west. The aviator who desires to make a record breaking trip by taking advantage of the strong winds aloft should, and generally does, consult the Weather Bureau to find out the odds in his favor.

[5] *The wind factor in flight: An analysis of one year's record of the Air Mail.* MO. WEATHER REV., March, 1923, 51: 111-125.

UPPER AIR OBSERVATIONS AT SEA.

Because of the experimental work being carried on by the U. S. S. *Langley*, it has been impossible to make flights with the Aerograph as no planes or pilots have been available for this work.

On Thursday September 13, 1923, while the *Langley* was en route from Boston, Mass., to Norfolk, Va., and after flying exercises had been carried out, one Vought plane was assigned to make an aerological flight.

At this time the *Langley* was off the Virginia coast, and after the plane had been equipped with the Friez aerograph, the Schneider altigraph, and a Navy pocket altigraph, Lieut. Braxton Rhodes as pilot and Chief Quartermaster Williams as aerological observer, took off from the deck of the *Langley* and made an aerological flight to 15,000 feet.

In ascending to this altitude four separate layers of cloud forms were gone through. Nothing of importance concerning the weather was gained by this flight, the conditions being normal.

As before, it was found that the vibration was too great to expect accurate results from the Friez aerograph, although an entirely new method was used in attaching the instrument, but by experimenting during the flight it was learned that by making minor changes, the effect of vibration will be nearly or completely eliminated.

In the history of upper air observations this is the first time that an aerological flight has been made from the deck of a moving vessel at sea, and while the plane landed at the naval air station, Hampton Roads, Va., it is known, from past experiments, that it could have landed aboard the *Langley* just as it had taken off.

From this flight, then, it can be seen that in the near future, with the development of aircraft carriers, a regular schedule of upper air observations can be carried out while these vessels are at sea, and the results obtained used in compiling data heretofore not obtainable.—*Franklin G. Williams, C. Q. M., U. S. Navy.*

THE ANTICYCLONE OF SEPTEMBER 12-18, 1923.

By ALFRED J. HENRY.

[Weather Bureau, Washington, D. C., October 17, 1923.]

In the previous number of this REVIEW[1] some comment was made upon the appearance of the first pronounced anticyclone of the season in the Canadian Northwest. In this number it is proposed to discuss in like manner the origin and movement of another larger and more enduring anticyclone that completely dominated the weather of eastern United States and Canada September 13-18, 1923.

In reality there were two anticyclones; the first is plotted as track No. VII and the second as track No. VIII of Chart I of this REVIEW. For convenience these will be referred to as the "first" and "second" anticyclone.

The barometric situation.—The barometric situation on the 10th was as follows: A trough of low pressure (29.9 inches) stretched from Minnesota south-southwest to Texas and an anticyclone (30.2 inches) covered the Lake region with a second anticyclone (30.2 inches) apparently moving southeastward from the Province of Alberta, attended by a sharp fall in temperature in western Saskatchewan and Assiniboia.

Subsequent development.—The Alberta anticyclone above mentioned advanced to eastern Montana in 24 hours and apparently continued to move in a southeasterly direction, although its identity after the 11th can not easily be distinguished.

On the morning of the 12th a fresh anticyclone (30.4 inches) appeared at Prince Albert, Saskatchewan, a sta-

[1] Henry, A. J.: The first cool wave of 1923 in the Dakotas and Lake region. MO. WEATHER REV., 51: p. 402.

tion on the extreme northern limit of the weather map. This anticyclone, which will hereinafter be designated as the second anticyclone and with which we are chiefly concerned, moved rather rapidly southeastward and eastward, crossing the Great Lakes on the 15th and 16th, disappearing off the coast of the Middle Atlantic States on the 18th; it brought frost and freezing temperatures to the northern interior border States and to the interior of New York and northern New England. This anticyclone belongs to the class sometimes referred to by United States Weather Bureau forecasters as "reinforced HIGHS" because of the fact that they descend from the Canadian Northwest directly upon an existing anticyclone which may lie athwart its path. In some cases a very slight fall in barometric pressure can be detected immediately in the rear of the anticyclone which apparently obstructs the path of the second anticyclone, but in many other cases such a fall can not be detected with observations separated by a 12-hour interval. A characteristic of this and other anticyclones of the same class is a tendency toward a rise in the level of the barometer in the central area as the anticyclone passes eastward. An explanation (it may not be the true one), would ascribe the rise in pressure to a strong inflow, mostly aloft, of dense air, the strength of the inflow being a function of the intensity of the cyclone center that immediately preceded the anticyclone.

Central pressure rose to 30.5 inches on the morning of the 16th and the rise was coincident with the disappearance of the cloud layer associated with the central area of the anticyclone, which doubtless prevented nocturnal radiation from cooling the atmosphere in that particular region.

Antecedent conditions.—Returning now to a consideration of the barometric situation as described in a previous paragraph, let us first consider the trough of low pressure. The width of the trough, counting from the 30-inch isobar on each side, ranged from 500 miles in the latitude of Oklahoma to less than 250 miles in Iowa. A weak cyclonic circulation can be detected in northeastern Kansas, but in general the surface winds in the trough were light south to southeast; in the free air, as at the kite stations of Ellendale, N. Dak., Drexel, Nebr., and Broken Arrow, Okla., the southerly surface winds shifted to southwest and west winds at a comparatively low level and the velocity diminished almost to zero. On the extreme west margin of the trough light northwest to north winds prevailed and we recognize at once the condition frequently referred to as a system of opposing winds. Strictly speaking the winds are not opposing, but rather one branch of the system—the north winds—approaches the other at a rather large angle instead of head-on, and being of greater density underruns and displaces the other. Eventually these two systems may unite, or merge with the prevailing west winds at about 4 kilometers. At the top of the warm southerly winds in this particular case and probably in other cases, there is found a region of marked discontinuity in the speed and direction of the wind, the extent of which can not be determined by the use of kites, since the wind speed diminishes to near zero. The southerly winds at each kite station here considered diminished in speed, as just stated, but on the contrary the northerly winds *increased* in speed with increase in altitude.

The contrast in temperature between these two wind systems must be much more pronounced in the cold than in the warm season and in this increase may be found the explanation of the greater driving power of the winter circulation.

The transition from summer to winter.—The change in the weather types begins in late summer or early autumn; it is accomplished not in a steady and uniform march from high to low temperature but rather in a series of steps at irregular intervals. At the conclusion of each step the general mean temperature is several degrees lower than it was at the beginning of the step and when a rise in temperature begins, as it must every few days, it must start from an initial point several degrees lower than was the case previously. The northerly winds being cooler than the southerly penetrate farther and farther to the southward as the season progresses and thus the change from the maximum of summer to the minimum of winter is brought about.

Free air winds in front of the anticyclone.—As just indicated the free air winds on the northwest side of the barometric trough were colder and thus of greater density than those from the opposite quarter. Some details from the kite flights will now be given. On the 10th the maximum velocity of the winds at 4 kilometers above Ellendale was 23.2 m. p. s. (51.9 m. p. h.). At Drexel on the same date, that station being within the barometric trough before referred to, the minimum velocity of the flight, 1.2 meters p. s. (2.7 m. p. h.), was reached at the top of the flight—1,442 meters above the surface at the station.[2] The kites, of course, were not able to ascend above that level. The Drexel station on the 11th came under anticyclonic influences (the first), and the wind direction was N.-NE. up to 1,500 meters (sea level) backing to W.-NW. at 1,536 and continuing in that direction to the top of the flight, 2,048 meters. The maximum velocity, however, was found about 500 meters above the surface, diminishing thence to the top of the flight.

On the 12th the Ellendale station came within the influence of the second anticyclone and the winds were then N.-NW., surface up to 1,000 meters, NW. 1,250 meters to 2,073 meters, then W.-NW. to 2,878 meters, the top of the flight and the maximum velocity, 23.3 m. p. s. was reached at the same level. Drexel on the same date apparently had not come within the influence of the second anticyclone, for we find the winds from the surface to 3 kilometers as being from the W. shifting to W.-NW. at 3,462 meters, then suddenly becoming NW. and so continuing throughout the descent to the surface. The maximum velocity, 28.7 m. p. s. (64.2 m. p. h.), was reached at the top of the flight. The significance of the shift of the wind to the NW. at the top is not clearly apprehended. On the following day when the center of the anticyclone was about 200 miles north of the Drexel station, the winds were NE. in the first 100 meters above the surface, E.-NE. the next 100 meters, then backing to NE. and so continuing up to 604 meters (above the surface). N. at 1,104 meters, N.-NW. at 1,604 meters and W.-NW. at 2,604 meters (surface) and so continuing up to the top of the flight at 3,921 meters (surface). The maximum velocity, 24.5 m. p. s. was reached at that level. From this and other cases the inference may be drawn that anticyclonic circulation of late summer may cease at say a little below 1,000 meters above the surface of the ground.

The temperature of the northerly winds.—When the shift to the north occurs the temperature of the north

[2] The tabular values of free-air conditions, as given by kite flights are referred to sea level as a base. The writer prefers to think of the temperatures referred to the ground as a base and for that reason has indicated in the text whenever altitude above the ground surface at the station is meant.

winds is not much different from that of its immediate surroundings, since it is air *in situ* that first begins to move toward the south. Temperature inversions with altitude may be experienced in air but recently set in motion toward the south, but by far the most pronounced inversions are found in the barometric minima which precede the anticyclone. Some mention of these will be made later. One would naturally expect the temperature of the air column in front of an oncoming anticyclone to be relatively low. At Ellendale on the 11th with the close approach of the anticyclone the kite flight could not be made until the afternoon, thus preventing an accurate comparison with the temperature of the different levels as recorded in the morning hours of the previous day. If, however, we take the levels above 1,500 meters the effect of diurnal variation is quite small and we get the following 24-hour changes:

At 2,000 meters a fall of 7.4° C.
At 3,000 meters a fall of 8.1° C.
At 3,500 meters a fall of 8.1° C.
At 4,000 meters a fall of 8.4° C.

The air column temperatures at Drexel on the same date were about 7° C. lower than on the preceding day, but here, too, an exact comparison is not practicable.

Large temperature inversions in southerly winds.—It is common knowledge that southerly winds in the free air are warm winds. For the dates in question there were rather frequent temperature inversions, the most pronounced were those noted at Ellendale on the 14th and 15th after the anticyclone had passed to the eastward and a new cyclone was approaching from the northwest.

On the 14th, with the cyclone center distant about 700 miles to the northwest, the actual temperature at the surface at Ellendale was 5° C. falling to 4.7° C. 54 meters higher and then rising to 13.5° at 556 meters above the surface; the top of the warm stratum was reached at 2,000 meters above the surface. On the following day with the cyclone center distant but 400 miles surface temperature in a south wind was 7.3° C., at the level 556 meters higher it had risen to 17.4° C. and at 2,000 meters the temperature was still higher than at the surface and the wind had become south-southeast in direct response to the barometric minimum in the northwest. On the next or third day the warm layer had reached the surface and the cyclone center at the same time had reached the meridian of the station. Thus we have an exact value of the rise in temperature in a S.-SW. current, not at the center of the cyclone but at a considerable distance to the southeast and not at the ground surface but at an altitude about 500 meters higher. It is to be noted, moreover, that this warm current was not deflected toward the cyclone center approaching from the northwest until the latter had approached to within 400 miles of Ellendale.

Discontinuities in wind speed and direction.—In this study the fact that the existence of a pronounced discontinuity in the free air can not be determined by the use of kites comes into prominence. Fortunately pilot balloon flights are made twice daily at kite stations. From the reords thus obtained it is possible to visualize the structure of the winds throughout a vertical distance of several kilometers. The morning kite-flight at Broken Arrow, on September 10, came to an end for lack of wind movement within 100 meters or so, of a current of moderate westerly winds (winds from the east) as was disclosed by the pilot balloon run of that morning. A pronounced discontinuity was found at the 2,250 meters level through which the kites were unable to pass. Above this level a current from the East was found having a depth of a little more than 2 kilometers and a maximum velocity of 13 m. p. s. The upper half of this westerly current fell off in velocity to less than 2 m. p. s. at 4,600 meters, where a second discontinuity was found. Above this level a W.-NW. current prevailed up to the 9.5 kilometer level, with a velocity at that level of 25 m. p. s.

In the pilot-balloon run made at 2:57 p. m. (90th Meridian Time) of the same date the discontinuities above mentioned had disappeared and the westerly current apparently had been replaced by one from the S. SE., extending through a vertical height of 3,700 meters above the surface. Above that level the wind backed through N. to NW. and a very deep and moderately strong current from the last-named direction prevailed up to 14 kilometers with the greatest velocity at the 12.5 kilometer level. On the morning of the following day the winds at 4.5 kilometers were W.-NW. becoming NW. at 6.7 kilometers and continuing thence to 13.7 kilometers as a deep W.-NW. current of relatively high velocity. The greatest velocity, 25.5 m. p. s. was found at the top of the run. This wind persisted throughout the 11th and 12th. In order the better to visualize the conditions that were found on the 10th the two pilot balloon runs have been plotted in Figure 1, the morning run at the top and the afternoon run at the bottom. A marked discontinuity in the speed and direction of the wind was disclosed on the 11th in the morning run only to disappear in the afternoon run. Under certain conditions the lower layers of the atmosphere may contain many discontinuities and "near" discontinuities.

The writer can not but feel that he has only scratched the surface of this interesting problem. It is of course hazardous to draw conclusions from but a few examples but the excellent agreement among those examined leads to the suspicion that they may have been representative of average conditions. With this limitation in mind the following may be presented as the outstanding features of this brief study: (1) The very considerable stratification of the atmosphere as regards wind direction and speed; (2) the shallowness of anticyclonic circulation in late summer; (3) the prevalence of northerly winds far in advance of the anticyclone center at an altitude of 5 or 6 kilometers.

Discussing very briefly the forecasting value of each of these features, it may be said that the stratification of the atmosphere as to wind direction and speed need not be surprising since the temperature and probably the pressure are frequently in that condition. Neither should it occasion surprise to find that the anticyclonic circulation disappears at a relatively small distance above the surface. This is in accord with a belief that has been growing within recent years. Effort should be put forth to determine the elevation at which it disappears on the average of all seasons.

As this paper was being finished a pilot-balloon run was made at Washington, D. C., p. m. of October 18, 1923. This run disclosed a zone of light, variable winds extending to the 6-kilometer level surmounted by a layer of northerly winds having a speed of nearly 20 m. p. s. The run at Aberdeen, Md., at the same time reached a level of 12 kilometers and showed a NNE. wind at that level of 20 m. p. s., thus substantiating the Washington record.

At the time these runs were made Washington was on the eastern margin of a large depression that was centered over the lower Ohio Valley, moving northeastward.

Four days later the Ohio Valley and the Lake region were occupied by a rather strong anticyclone. In the judgment of the writer the northerly winds observed at Washington and Aberdeen can not be considered as foreshadowing the appearance of the anticyclone, as above mentioned. In the case of the northerly winds observed at Broken Arrow on September 10, as hereinbefore mentioned, the anticyclone of that date passed to the eastward rather than to the southward and thus over the Oklahoma station. Later in the season strong anticyclones will probably pass from the Dakotas directly southward to the Gulf of Mexico and thus will afford the opportunity of studying in detail the structure of the atmosphere in these pronounced features of atmospheric cooling.

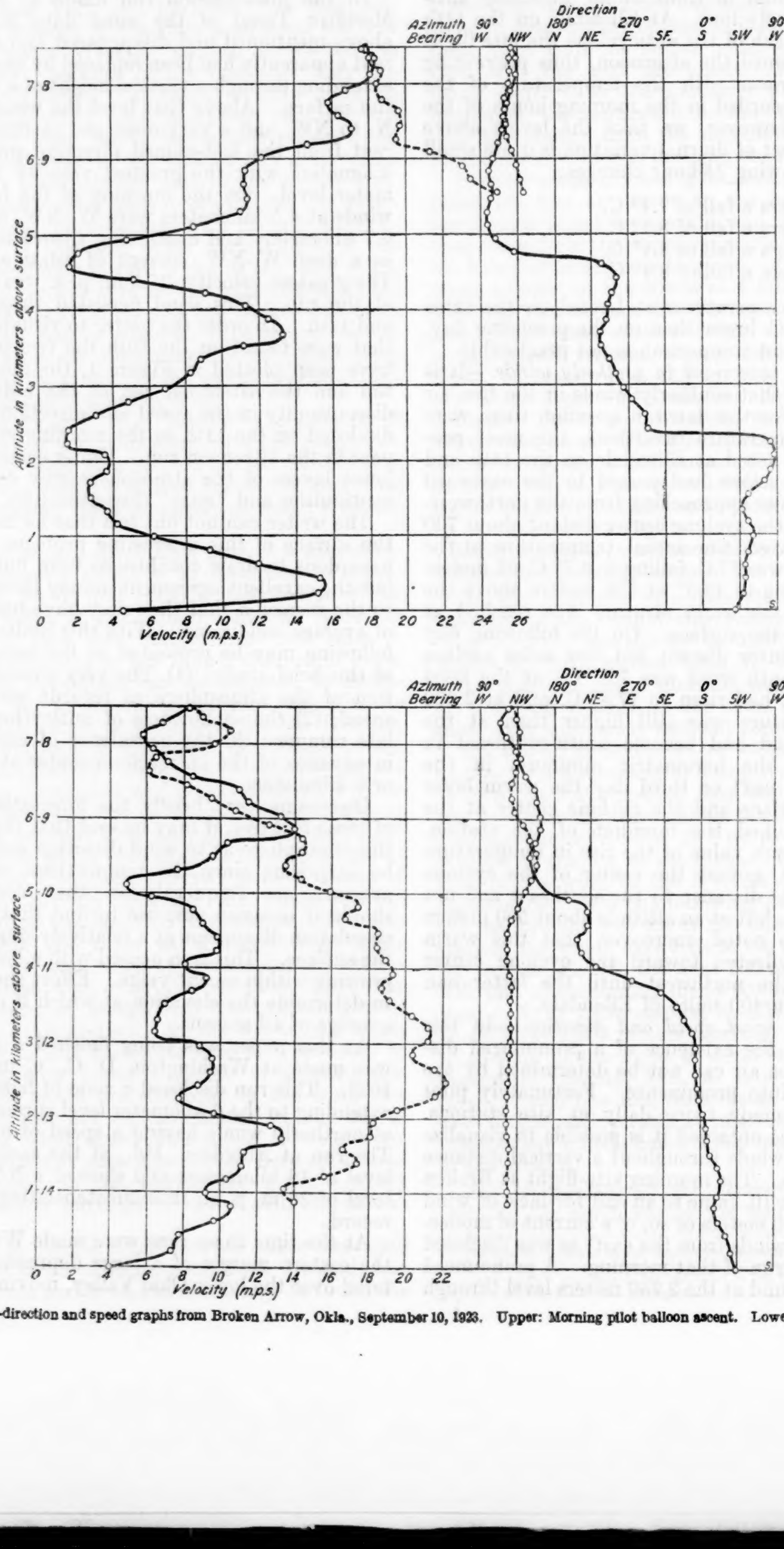

FIG. 1.—Altitude-direction and speed graphs from Broken Arrow, Okla., September 10, 1923. Upper: Morning pilot balloon ascent. Lower: Afternoon ascent.

FREQUENCIES OF MONTHLY AND SEASONAL RAINFALLS OF VARIOUS DEPTHS AT SAN JOSE, CALIF.

By ESEK S. NICHOLS, Meteorologist.

[Weather Bureau Office, San Jose, Calif., September 6, 1923.]

The fact that a statement of monthly and annual averages of precipitation gives a very inadequate idea of the variation from month to month and from year to year is well illustrated by the rainfall record of San Jose, which is situated in the Santa Clara Valley of California near the southern end of San Francisco Bay.

Since July 1, 1906, the official rain gage, which is of the standard tipping-bucket self-recording type, has been exposed in City Hall Park with the top of the collecting funnel 3 feet above ground. The records for the 17-year period since that date form a homogeneous series. Also, there are available readings for the 32 years immediately preceding, mostly taken by cooperative observers in various locations about the city; and for a few months made at the former location of the regular Weather Bureau station previous to its destruction during the great earthquake and fire of April 18, 1906.

Table 1 gives the individual monthly, seasonal, and yearly amounts of rainfall for the 17-year period, September, 1906, to August, 1923, inclusive, years beginning with September 1; and the monthly, seasonal, and annual averages for the same 17-year period, as well as for the entire 49-year period beginning September 1, 1874.

TABLE 1.—*Monthly, seasonal, and annual precipitation at San Jose, Calif., 1906–1923.*

Year.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Fall.	Winter.	Spring.	Summer.	Total.
1906-7	0.13	0.01	0.98	6.39	4.61	1.88	7.75	0.46	0.08	0.42	T.	0	1.12	12.88	8.29	0.42	22.71
1907-8	0.06	0.98	0.13	3.65	2.63	2.46	1.14	0.23	0.67	0.01	0	0	1.17	8.74	2.04	0.01	11.96
1908-9	0.09	0.19	1.11	1.54	7.69	4.87	2.77	0	0	0.05	0	0	1.39	14.10	2.77	0.05	18.31
1909-10	0.75	0.72	1.27	5.41	2.31	0.83	2.84	0.41	T.	0.02	T.	0	2.74	8.55	3.25	0.02	14.56
1910-11	0.09	0.20	0.28	0.68	12.38	2.03	6.26	0.45	0.21	0.07	T.	0	0.57	15.09	6.92	0.07	22.65
1911-12	0	0.80	0.18	2.03	1.36	0.30	2.80	1.95	0.70	0.46	T.	0	0.98	3.69	5.45	0.46	10.58
1912-13	0.71	0.21	0.29	0.43	2.29	0.09	1.17	0.38	0.77	0.01	0.09	0.08	1.21	2.81	2.32	0.18	6.52
1913-14	T.	0.02	4.10	3.00	6.23	3.94	0.90	0.65	0.19	0.25	0	0	4.12	13.17	1.74	0.25	19.28
1914-15	0	0.50	1.36	3.73	4.85	7.02	1.49	1.07	2.69	0	0	0.04	1.86	15.60	5.25	0.04	22.75
1915-16	0	0	0.19	4.37	8.71	1.83	1.10	0.06	0.01	T.	T.	0.01	0.19	14.91	1.17	0.01	16.28
1916-17	0.78	0.84	0.41	3.48	0.98	4.88	0.77	0.26	0.22	0	T.	0	2.03	9.34	1.25	T.	12.62
1917-18	0.01	0	0.54	0.55	0.70	2.63	4.48	0.45	T.	0	0	0	0.55	3.88	4.93	0	9.36
1918-19	6.33	0.15	2.24	1.28	1.06	4.87	2.87	0.06	0.01	T.	T.	0.01	8.72	7.21	2.94	0.01	18.88
1919-20	0.25	0.28	0.09	2.48	0.10	1.04	3.43	0.92	T.	0.21	0	0	0.62	3.62	4.35	0.21	8.80
1920-21	0.02	1.71	1.84	3.58	4.75	1.09	0.80	0.40	0.82	T	0	0	3.57	9.42	2.02	T.	15.01
1921-22	0.21	0.21	1.65	4.66	2.46	3.01	1.74	0.32	0.50	0.01	T.	T.	2.07	10.13	2.56	0.01	14.77
1922-23	0	1.55	2.72	4.63	1.93	1.02	0.31	1.52	0.02	0.10	0	.01	4.27	7.63	1.85	0.11	13.86
17-year averages	0.55	0.49	1.14	3.06	3.83	2.58	2.51	0.56	0.41	0.09	T.	0.01	2.18	9.47	3.48	0.10	15.23
49-year averages	0.35	0.72	1.50	2.64	3.05	2.45	2.66	1.08	0.55	0.11	T.	0.02	2.57	8.14	4.29	0.13	15.13

On the line diagram, Figure 1, have been plotted both the 17-year and the 49-year monthly averages. The dry summer and the comparatively wet winter typical of Pacific coast climates are clearly shown. If the February amount were corrected for length of that month,

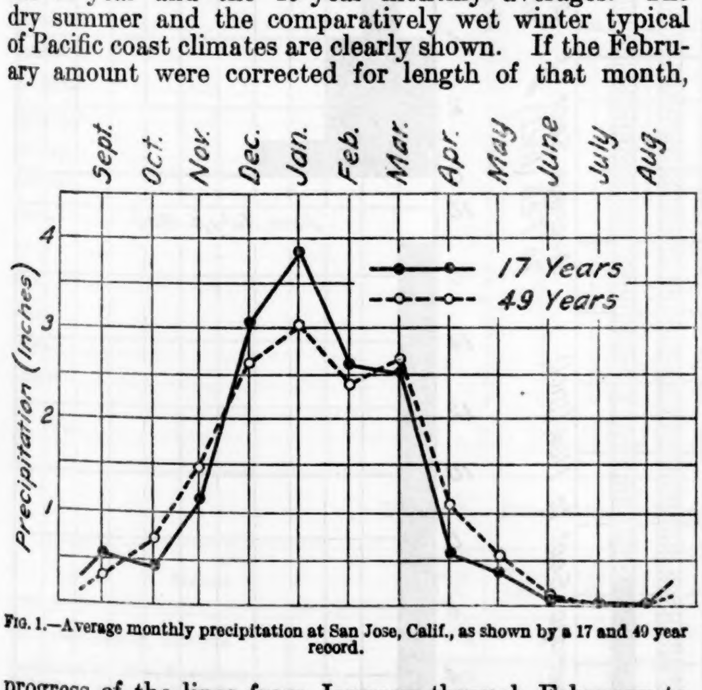

FIG. 1.—Average monthly precipitation at San Jose, Calif., as shown by a 17 and 49 year record.

progress of the lines from January through February to March would be smoothed considerably. The longer record gives the smaller winter averages; but larger in spring and fall; and the yearly totals are practically identical, showing that San Jose's climate is not changing in this respect, at least.

Figure 2, based on a portion of Table No. 1, is a bar diagram that shows the progressive totals by tri-monthly seasons beginning with September for each year of the 17-year period considered. The amounts of precipitation are shown by lengths of vertical bars as measured by the scale of inches at the left of the diagram. The lengths of the lowest sections of the bars, unshaded, and the height of the lowest horizontal line above the base indicate, respectively, the individual seasonal and the average totals for the trimonthly period (season), September to November, inclusive.

Similarly, the lengths of the next higher sections of the several bars (shaded longitudinally) give the individual seasonal totals for December to February, inclusive, and the height of the second horizontal line above the first shows the average total for these three months. Of course, the heights of the tops of the several longitudinally shaded sections, and of the second horizontal bar, above the base indicate, respectively, the individual seasonal and the average totals from September to February, inclusive. Likewise, the spring and summer totals, the annual totals, etc., are shown by the third (clear) and the fourth (crosshatched) sections of the bars and by the third and fourth horizontal lines above the base.

No clear evidence of periodicity appears in Figure 2; but in two cases a pair of dry years was preceded by a trio of wet ones. A cursory inspection of Table 1 and of Figure 2 shows that average values are not more likely to occur than are amounts differing considerably therefrom. This is graphically shown by the frequency diagrams, Figures 3 and 4, in which the numbers of times the total monthly, seasonal, and annual precipitation

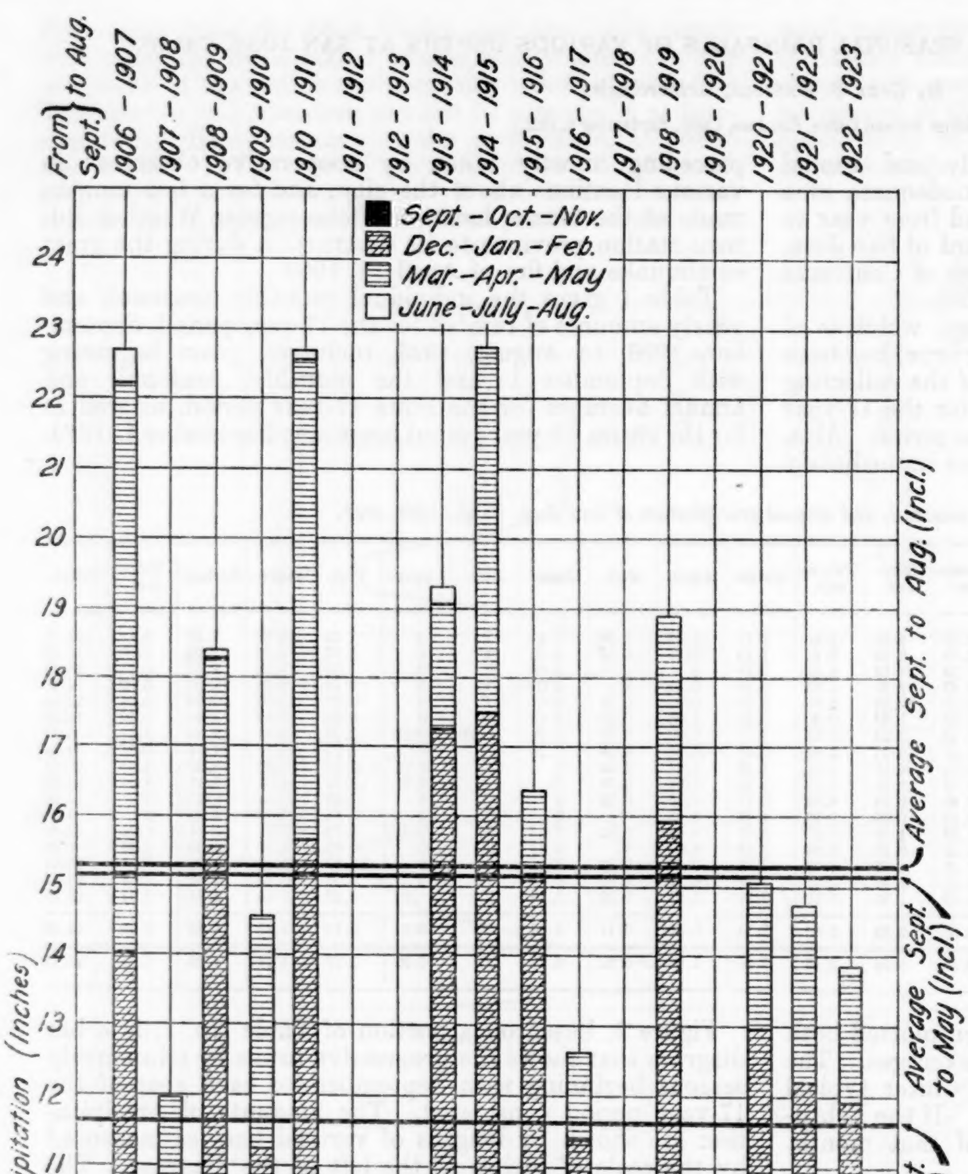

FIG. 2.—Seasonal precipitation, San Jose, Calif., September, 1906, to August 1923, inclusive.

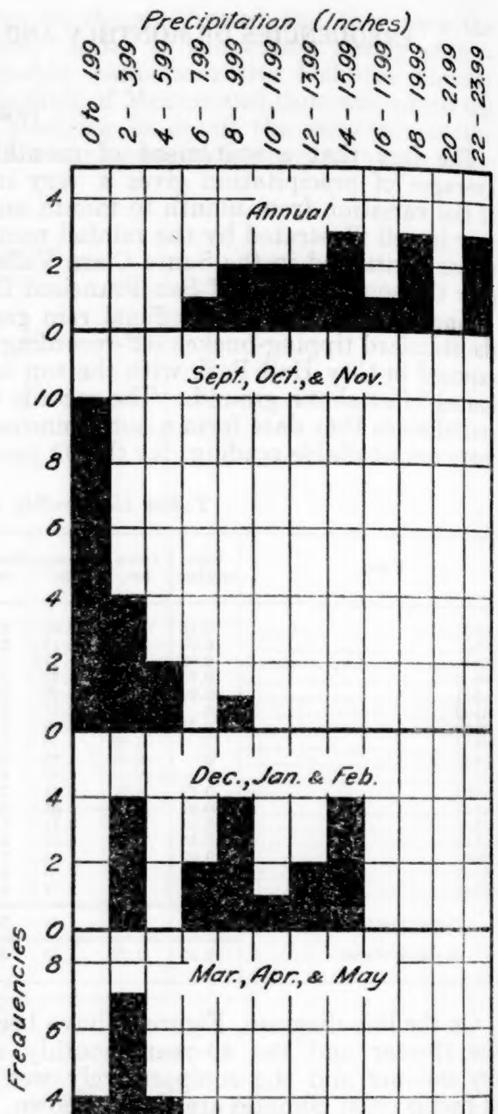

FIG. 3.—Trimonthly and annual precipitation frequencies at San Jose, Calif.

lay between certain limits are given by the lengths of bars as measured by scales at the left of the diagrams.

Figure 3 has a section for the year and one for each quarter year (of three calendar months), beginning the year September 1; and gives the frequencies for our 17-year period in 2-inch classes, beginning with 0 to 1.99 inches as the lowest class. This figure shows that the most frequent amount (that is, the "mode") for the fall months, September, October, and November, inclusive, is less than 2 inches; that the summer rainfall invariably falls within this lowest class; that the most frequent in spring is the second class, 2 to 3.99 inches; that winter amounts vary widely, the second class being as frequent as the eighth (14 to 15.99 inches); that annual amounts vary widely also.

Figure 4 has a section devoted to each month of the year. As the 17-year record shows no pronounced mode for certain months the preceding 32-year record (using data tabulated in section 14, "Climatological data for the U. S. by sections") has been added by proper lengthening of the several bars; 17-year record crosshatched, 32-year, clear. Here we have used half-inch intervals in classifying the precipitation.

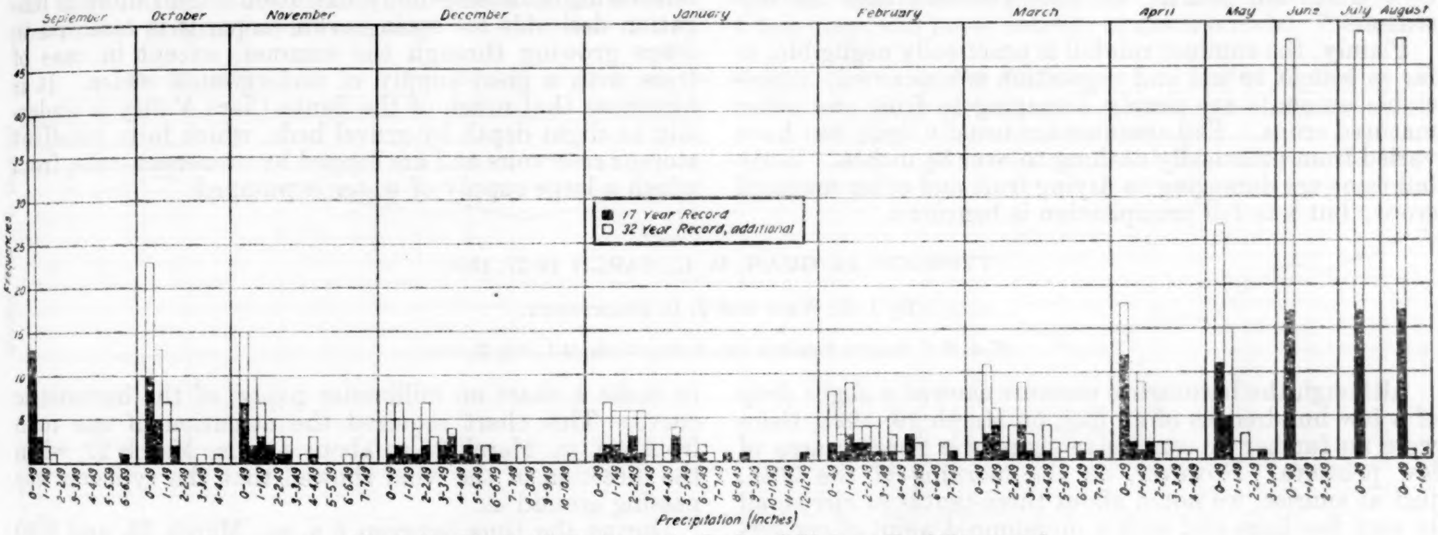

FIG. 4.—Monthly precipitation frequencies, San Jose, Calif., from a 17 and 32 year record.

TABLE 2.—*Precipitation frequencies at Santa Clara, Calif., for 17 years and 49 years, respectively.*

	0.00 to 0.49.	0.50 to 0.99.	1 to 1.49.	1.50 to 1.99.	2 to 2.49.	2.50 to 2.99.	3 to 3.49.	3.50 to 3.99.	4 to 4.49.	4.50 to 4.99.	5 to 5.49.	5.50 to 5.99.	6 to 6.49.	6.50 to 6.99.	7 to 7.49.	7.50 to 7.99.	8 to 8.49.	8.50 to 8.99.	9 or more.	Total.
September	13	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	17
	27	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
October	10	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	13	8	7	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	32
November	7	2	3	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	17
	8	8	4	3	2	2	0	1	2	0	0	0	1	0	1	0	0	0	0	32
December	1	2	1	1	2	0	2	3	1	2	1	0	1	0	0	0	0	0	0	17
	6	5	4	3	5	3	0	1	0	0	0	2	0	0	0	2	0	0	1	32
January	1	2	2	1	3	1	0	0	0	3	0	0	1	0	0	1	1	1	0	17
	0	5	4	5	3	5	2	2	1	1	1	1	1	1	0	0	0	0	0	32
February	2	1	3	2	2	1	1	1	0	3	0	0	0	0	1	0	0	0	0	17
	6	2	6	2	2	3	4	2	1	0	2	0	0	2	0	0	0	0	0	32
March	1	3	4	1	0	4	1	0	1	0	0	0	1	0	0	1	0	0	0	17
	1	8	2	1	4	5	2	0	3	2	1	2	1	0	0	0	0	0	0	32
April	12	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	6	8	8	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	32
May	11	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	16	10	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
June	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	31	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
July	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
August	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
Year	109	25	14	11	8	8	4	4	3	8	1	0	4	0	1	2	1	1	0	204
	177	57	39	23	20	20	10	7	9	3	4	5	3	3	1	2	0	0	1	384

TABLE 3.—*Precipitation frequencies: Seasonal and annual, 17 years.*

Periods.	0 to 1.99.	2 to 3.99.	4 to 5.99.	6 to 7.99.	8 to 9.99.	10 to 11.99.	12 to 13.99.	14 to 15.99.	16 to 17.99.	18 to 19.99.	20 to 21.99.	22 to 23.99.	24 to 25.99.	26 to 27.99.	Total.
September-August, inclusive	0	0	0	1	2	2	2	3	1	3	0	3	0	0	17
September, October, November	10	4	2	0	1	0	0	0							17
December, January, February	0	4	0	2	4	1	2	4							17
March, April, May	4	7	4	1	1	0	0	0							17
June, July, August	17	0	0	0	0	0	0	0							17
Trimonthly	31	15	6	3	6	1	2	4							68

Amounts for each June, July, and August of the entire 49 years fall within the lowest class (less than one-half inch), with the exception of one June and one August. The same class is plainly the mode for September, October, November, April, and May; and is very frequent in the early 32-year record for December and February, although other classes are equally or somewhat more frequent. Several classes are about equally frequent in January, all above one-half inch. The four months, December to March, inclusive, have no one strongly out standing class, but show wide variations. March has two modes, the second and sixth classes, probably because this is a transition month, between the wet and the dry seasons.

Plainly, the summer rainfall is practically negligible, as far as benefit to soil and vegetation is concerned; appreciable amounts are simply damaging to fruit and other matured crops. Fall amounts are usually light, but have varied from practically nothing to over 8½ inches. Early fall rains are damaging to drying fruit and other matured crops; but late fall precipitation is beneficial.

The greatest amounts usually fall in winter, though sometimes spring is ahead, and in one very exceptional case fall produced more than any other quarter of the year. Spring amounts are variable, but are sufficient to benefit growing vegetation.

Dry seasons and months are more frequent than wet ones; excesses are greater than deficiencies; the mode is less than the mean. For instance, the November average is over 1 inch, but the most probable amount for that month is less than one-half inch. The annual totals have varied from about 6.5 to 22.5 inches (during the 17-year period); in some seasons the amount is so slight that even fall-sown grains benefit by irrigation. Still more is irrigation desirable for spring-sown crops; it is essential to crops growing through the summer, except in case of trees with a good supply of underground water. It is fortunate that much of the Santa Clara Valley is underlain at slight depth by gravel beds, which form excellent storage reservoirs and are tapped by numerous wells, from which a large supply of water is pumped.

TYPHOON AT GUAM, M. I., MARCH 19-27, 1923.

By J. H. WEST and J. D. SWARTWOUT.

[U. S. M. C. Scouting Squadron One, Sumay, Guam, M. I., July 27, 1923.]

Although the barometric pressure showed a slight drop of a few hundredths of an inch on March 19, 1923, there were no further or conclusive signs of a nearing area of low pressure. However, on the morning of the 20th, just at sunrise, we noted about three-tenths of cirrus, all in very fine lines and with a pronounced point of convergence in the SE. The signs were unmistakable. The pressure on the 20th reached a maximum of 29.89 inches at 10 a. m., while on the 19th the maximum was 29.91 inches at 9 a. m. The minimum pressure on the 19th was 29.83 inches at 4 p. m. and on the 20th 29.80 at 3 p. m. The approach of an area of low pressure was recorded in the Aerological Journal on the 20th.

The pressure continued to drop slowly for three days without any effect on the diurnal variation.

We had observed similar occurrences before lasting from two to five days. After the first day in which the pressure dropped in these previous occurrences, the wind had shifted slightly each day, showing that the center of the depression was passing around us. The winds from March 19 to 22, inclusive, did not shift at all, but blew steadily from a general ENE. direction, the highest velocity during that time being recorded as 22 miles per hour, at 3 p. m. on March 21.

On the 23d the winds shifted slightly to the N., coming from NE. and NNE. and increasing to a velocity of 27 m. p. h. at 9 p. m. Up to March 23, cirrus and cumulus had been the predominating clouds, but on the 23d from three to five tenths of cirro-stratus, strato-cumulus, alto-stratus, and stratus were recorded at different times throughout the day.

The morning of the 24th this office issued a typhoon warning, which was sent through the commanding officer of Scouting Squadron One, this office not being allowed to broadcast any messages directly, as all communications must go through official channels.

From midnight of March 24 eye readings of the mercurial barometer were taken at 30-minute intervals or oftener, up to 3 p. m. on the 25th, when we started to take readings of the barometer and wind direction and force at 12 and finally 6 minute intervals. At Lieutenant Swartwout's suggestion and with his aid we started to make a chart on millimeter paper, of the barometric curve. This chart required the attention of one man from 8 a. m. March 25 to about 4 a. m. March 27, when the direction of the wind showed that the typhoon was passing around us.

During the time between 8 a. m., March 25, and 8:40 a. m., 27th, the anemometer buzzer was connected with extra batteries and fixed so that it buzzed continuously. By noting the sudden increase in the number of buzzes, and counting them for five-second periods, gusts were recorded as high as 156 m. p. h. This highest velocity was reached at 3:24 and 3:30 a. m., March 26. At 8:40 a. m. the 26th the anemometer cups were blown away and no further wind velocities could be obtained.

The wind showed a slight shift about midnight the 25th, registering then about 70°. Throughout the 26th the wind showed a tendency to move farther toward the south and by midnight this date it was coming from 155°.

The rainfall during this period was quite heavy. On the 24th there was about 0.44 inch, on the 25th 2.01 inches, 26th, a continuous rain throughout the day registered 4.84 inches and on the 27th in the a. m. 0.85 inch. This is not absolutely the correct amount of rain for that period, as proper care could not be given to the instruments after one of the men in the aerological office was severely injured, leaving only two men.

The remarkable feature of the typhoon was the large, but slow, pressure drop, and the conspicuous diurnal effect which shows clearly even at the point of lowest pressure. The slow, steady, drop was indeed very puzzling to us during the first few days of the low pressure. Our first theory, that the typhoon was moving toward us from the SE. and that it was about 200 miles away when we first started to feel its effect, had to be discarded. It took practically seven days for the barometer to reach its lowest point after it started dropping. Even if the typhoon had been moving at the slow rate of 5 miles an hour and had been 200 miles away when we first started to feel its effect, it would have been about 650 miles past us by the time the pressure here was the lowest. Suppose the typhoon had been traveling at the

rate of 8 miles an hour, then it must have been over 1,000 miles away when the pressure here started to fall. In such a case the barometric gradient would have been steeper and the intensity far greater than it was.

Our logical conclusion then was that a large area of low pressure was forming very near here and was slowly developing into a typhoon. In developing from a large area of low pressure, a typhoon in this region will take several days to form. There is no progressive movement during this development and, even after the typhoon has formed, its progressive movement the first few days is very slow. It is our opinion that the typhoon formed less than 100 miles from here and passed us at a very slow rate of progressive movement.[1]

from 4 a. m. to noon on the 27th, the time of the first marked rise, there was no diurnal effect, although the curve dropped slightly in the afternoon.

The damage done to the island by the typhoon was by far the worst on the south end, the north end of the island being effected but little. In the towns of Merizo, Inarajan, and Tarafofo, and the ranches around these towns the damage was quite heavy, destroying practically all the crops, washing out bridges, and even to a large extent demolishing the coconut palms.

In several spots of the old Spanish road between Inarajan and Merizo the sea had washed out large deep cavities, and in some places the old roadbed was almost 4 feet deep, and made entirely of cascajo rock. Evidence

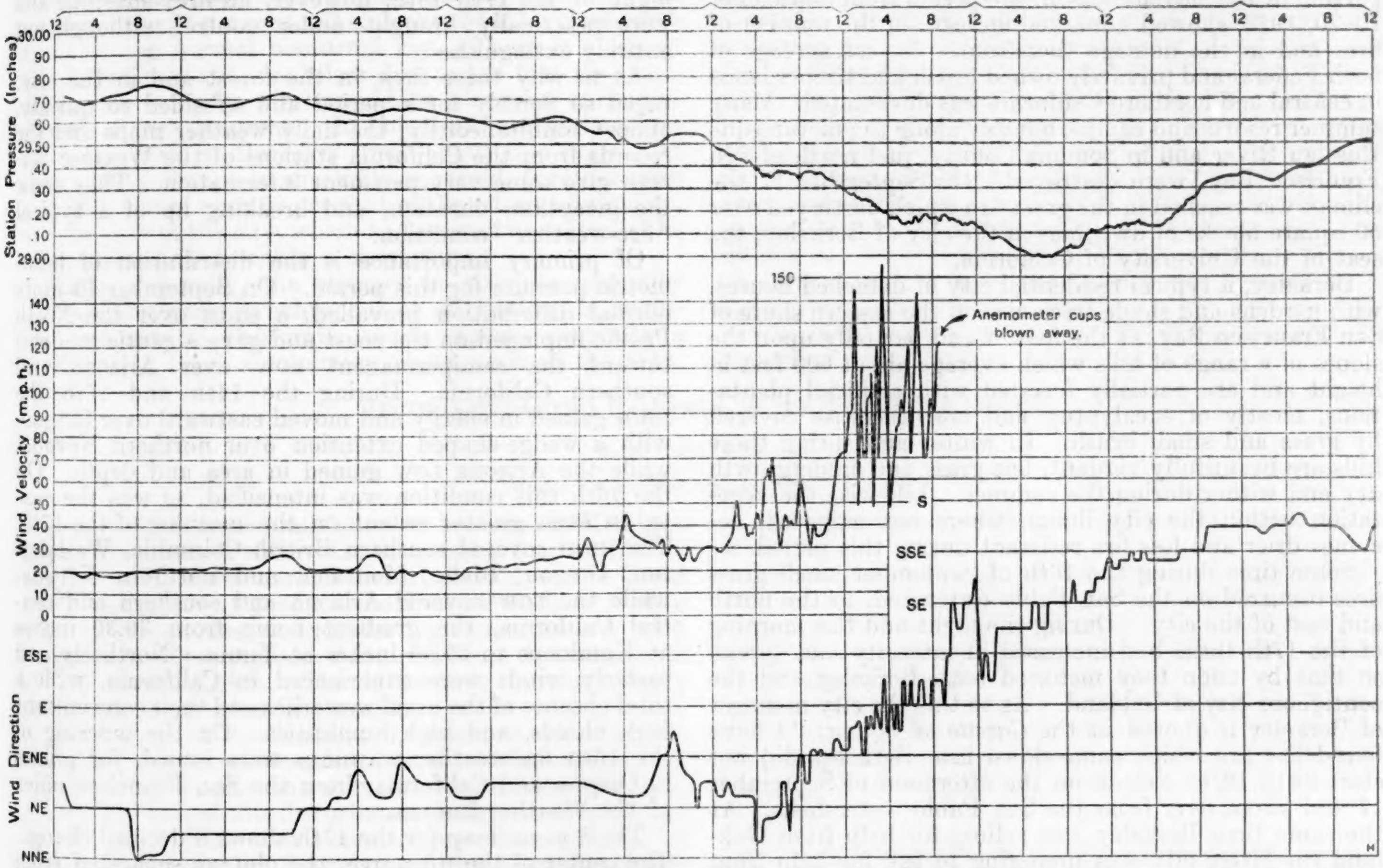

FIG. 1.—Record of station pressure, wind velocity, and wind direction during the period Mar. 23-27, 1923, at Guam, M. I. Data plotted from eye readings of mercurial barometer, and indications of buzzer anemometer.

This theory would account for the slow steady drop in pressure, and as the typhoon formed and passed us very slowly and then moved on faster as the shifting of the wind denoted, the slow rise of the pressure at first and then the faster completion of its rise to normal. In this way we can explain the failure of the typhoon to have any marked effect on the diurnal curve, as an area of low pressure would not have the same effect as a fully developed typhoon. The diurnal curve was more pronounced on the 28th and 29th, showing a tendency, toward normal again as the typhoon moved farther away, while

[1] The conclusions reached by Messrs. West and Swartwout might be supplemented as follows: The westward movement of the typhoon brought it very close to the island and it evidently recurved just west of Guam, the recurve being in part responsible for the slow movement. The Northern Hemisphere weather maps of the Weather Bureau show the typhoon as passing Bonin Islands on the 29th and later being encountered by a vessel in the North Pacific although then greatly diminished in energy.—EDITOR.

of the sea washing for distances of a quarter of a mile inland was plentiful. All the telephone lines and most of the small sapling poles were down all along, and once in about every mile could be found a thatched roof or even a whole shack that had been swept from its four-poster foundation. The natives seemed to be happy that the damage was no worse than it had been in the typhoon of July, 1918. Their heaviest loss seemed to be in having to abstain from their tuba drink until the coconut trees recovered from the effects of the high wind.

Temporary communication lines were put up by a party of men from the aviation unit and in a few days everything was much the same as before the storm. No lives were lost and only a few unavoidable accident occurred.

WEATHER AND THE BERKELEY FIRE.

By GEORGE W. ALEXANDER.

[Weather Bureau Office, San Francisco, Calif., Oct. 15, 1923.]

Each recurrence of the dry, almost rainless, summer, which is a characteristic of the climate of California, witnesses a period during which the forest-fire hazard throughout the State is normally quite acute. August and September are the months of greatest danger, being marked by a minimum of rainfall and a maximum of campers, hunters, and other visitors to the hills and mountains, their carelessness being responsible for the origin of most of the fires.

As compared with other years and with the preceding portion of the current season, the period from September 10–20, 1923, showed a marked increase in the number of fires and in the damage therefrom. A vast acreage of both Federal and privately owned brush and timber lands in central and northern California was devastated. Many summer resorts and camps, notably along the picturesque Russian River and in Sonoma County, just north of San Francisco Bay, were destroyed. On September 17 the climax was reached in the great fire which destroyed over 50 square blocks of dwellings in the city of Berkeley, the seat of the University of California.

Berkeley, a typical residential city of detached houses, with gardens and shade trees, lies on the eastern shore of San Francisco Bay, at the foot of and partially upon the slopes of a range of hills which average about 600 feet in height and are partially forested with artificial plantations, mostly of eucalyptus, and are otherwise covered by grass and small brush. In winter and spring these hills are beautifully verdant, but grass and undergrowth dry and wither during the summer. Likewise the vegetation within the city limits, where not irrigated, becomes drier and less fire resistant during this period.

Some time during the 16th of September small grass fires occurred on the San Pablo watershed, to the north and east of the city. During the night and the morning of the 17th these had increased in intensity and spread so that by noon they menaced both Berkeley and the contiguous city of Oakland. As to this the city manager of Berkeley is quoted in the *Gazette* as saying: "I have found the fire which came down into Berkeley did not start until 12:15 o'clock on the afternoon of September 17 and swept over from the San Pablo watersheds. At the same time Berkeley was calling for help from Oakland the latter city was preparing to ask for help from Berkeley. There were six serious fires raging in Oakland, and in Berkeley the fire department responded to nine calls in 45 minutes at the time the city was being threatened by the more serious blaze." Fortunately the fire was held in the hills to the east of Oakland and no serious damage was done in that city.

In Berkeley, once the fire was communicated to the city itself, it spread rapidly, although all available forces were called on to combat it. The flames appeared uncontrollable, and despite the most strenuous opposition swept from block to block, destroying everything in their path; the bungalow of the commuter, more pretentious dwellings, fraternity chapter houses, residences of faculty members (Dr. Benjamin Ide Wheeler, president emeritus of the university, was one of the sufferers), were consumed. At one point the flames reached to the limits of the campus of the university itself. It seemed that the greater part of the city was doomed. But at about 5 o'clock in the afternoon the situation was changed for the better, the dry northerly wind which had continued for some 36 hours ceased and was replaced by a gentle southwesterly breeze from off the bay and the Pacific. Immediately the fires seemed to decrease in violence and within an hour were under control.

At the same time a similar condition obtained in the national forests in the State. On the 16th the fire situation in the California, Eldorado, Trinity, and Sierra Forests was very bad; during the night of the 16th and on the 17th the fires increased in fierceness and spread rapidly, about 25,000 acres being affected. During the night of the 17th–18th, however, all fires subsided and were practically brought under control, although not entirely extinguished.

As to why these fires, in the forest and in the city, raged so fiercely for a period and subsided so quickly, almost simultaneously, the daily weather maps and the records from the California stations of the Weather Bureau give some very pertinent information. They show the inception, duration, and breaking up of a typical "fire-weather" condition.

Of primary importance is the distribution of barometric pressure for this period. On September 13 quite normal distribution prevailed; a HIGH over the North Pacific impinged on the coast and gave a gentle gradient toward the semipermanent LOW over Arizona and southern California. During the 14th and 15th the HIGH gained in energy and moved eastward over Oregon, with a wedge-shaped extension over northern Nevada, while the Arizona LOW gained in area and depth. On the 16th this condition was intensified, as was the case to an even greater extent on the morning of the 17th. The HIGH covered southern British Columbia, Washington, Oregon, Idaho, Montana, and northern Nevada, while the LOW covered Arizona and southern and central California, the gradient being from 30.36 inches at Kamloops to 29.56 inches at Yuma. Northerly and easterly winds were experienced in California, with a total absence of the usual westerlies and their concomitant fogs, clouds, and high humidities. On the morning of the 16th fire-weather warnings were issued, for points in Oregon and California, from the San Francisco office of the Weather Bureau.

The 8 p. m. map for the 17th shows a decided change. The center of the HIGH over the plateau separated from that over the North Pacific and moved southeastward. Comparatively low pressure appeared over Alberta and Saskatchewan, with extensions toward the Arizona LOW. The northerly and easterly winds ceased or lost force. During the 18th the continental HIGH continued to move eastward, and by the 19th conditions were substantially the same as on the 13th. The type of pressure distribution shown on the 16th and 17th may be called an ideal one for the causation of Foehn or Chinook effects, easterly and northeasterly winds sweeping from the arid and semiarid plateau, the air mechanically warmed by compression during its descent into the California valleys, with extremely low relative and absolute humidity and its capacity for absorbing moisture greatly enhanced.

The curves of relative humidity at Berkeley and at San Francisco show a remarkable similarity. The most striking feature is the failure of the usual nocturnal rise for the night of the 16th–17th, which clearly indicates an abnormal condition. The humidity curves corre-

spond inversely, moreover, with the wind velocity curve for San Francisco. An interesting feature is the sudden rise in the humidity for San Francisco, followed by an equally sudden drop between 8 and 9 p. m. on the 16th, during which period the wind decreased in force and shifted for about half an hour from northerly to southerly. There is no record of wind direction for Berkeley, but anemometer records for the period of the rise in humidity there, 2 p. m. to 9 p. m., show very light winds, from 1 to 2 miles per hour, increasing to from 10 to 20 miles per hour at about 10 p. m., the time of the sudden fall in the humidity. Northerly winds continued, shifting through northeast and northwest, at San Francisco until about 3 p. m. on the 17th, when a shift to west occurred. A sudden rise in the humidity curve is synchronous with the shift in the wind, the percentage of relative humidity increasing from 21 per cent at 3 o'clock to 64 at 5 o'clock, with a continuing normal nocturnal rise. There is a lag in the Berkeley curve, doubtless due to the fact that normally the westerly wind would be observed earlier at a point nearer the ocean. In fact, fresh northerly winds were observed in Berkeley until about 5 o'clock. At that hour a change to southerly occurred, together with a sudden rise of over 60 per cent in the relative humidity. and the fires in the city, which had seemed uncontrollable, were extinguished within a short time.

While, naturally, the changes in absolute humidity are not absolutely synchronous at all stations in northern and central California, there appears generally a tendency to reach a minimum about noon of the 17th, with a rapid rise on or before 5 p. m. of that date, continuing for the next two days.

In the Pacific Northwest members of the Forest Service have established a definite correlation between the fire hazard and the percentage of relative humidity, the first increasing as the latter decreases. The effects of winds in aiding the spread of fires, forest or otherwise, are a matter of common knowledge. The records show that in California, for the period from the 14th to the 17th of September, all meteorological factors were such as to materially increase the fire hazard, namely, a gradual decrease in humidity, both relative and absolute, accompanied by strengthening winds from the north and east. These conditions reached their climax on the afternoon of the 17th, and it is a matter of record that the fires in the several parts of the State reached their climax of destructiveness at the same time. With the change in weather conditions during the night of the 17th the fires were brought under control. The conclusions of the Forest Service officials appear to be well founded.

In the Alpine regions, or in the Plains States of America, such a Foehn condition may cause only a welcome thaw and lessening of extreme cold; in California it causes a very unwelcome and dangerous increase in the ever-present menace of forest fires. Fortunately, such conditions can be forecast before reaching their maximum of danger, and it is believed, with the lessons of the September fires fresh in memory, the forecasts will receive more general attention from the public than has heretofore been the case.

RECORD-BREAKING RAINFALL IN SOUTHERN MICHIGAN.

R. M. DOLE, Observer.

[Weather Bureau Office, Lansing, Mich., Oct. 2, 1923.]

One of the heaviest rainfalls ever recorded in Michigan occurred on July 7, 1923. On the weather map of Friday, July 6, 1923, were marked disturbances over the Great Banks and also in Canada, some distance north of Winnipeg. Between was an irregular high pressure area with centers near Birmingham, Ala., and some distance north of the Great Lakes. The latter was moving slowly southward increasing in strength.

An offshoot of the Canadian disturbance moved southeastward, thence east-southeastward, and Saturday morning July 7, 1923, was central over southern Lake Michigan. North and east of this disturbance rising pressure blocked its progress. This distribution of pressure was ideal for heavy downpours in that part of the area of activity where the gradient was steepest and where the most resistance obtained, namely, in the northeast portion, which was over southern Michigan about the noon of Saturday, July 7, 1923.

Exceptionally heavy rains, accompanied by moderate lightning, fell in a narrow strip running north and north-northwest from Hillsdale County, through Jackson, Eaton, Ingham, Ionia, Clinton, Shiawassee, through Montcalm into the southern portion of Mecosta County, in the southern section of the Lower Peninsula of Michigan.

The rainfall was such as one encounters in the South, but is unusual for Michigan. The heaviest rainfall measured fell near Jackson, amounting to 3.34 inches (0.04 of an inch fell during the night). The observer there recorded the time as from 12:50 p. m. to 1:45 p. m., or less than one hour. At Lansing, in Ingham County, 2.33 inches fell from 9 a. m. to 2:30 p. m. In one hour the amount was 2.06 inches, exceeding all previous records for that length of time. The tabulated record follows:

	Minutes.										
	5	10	15	20	25	30	35	40	45	50	60
Rainfall........	0.05	0.16	0.36	0.41	0.45	0.63	0.96	1.33	1.65	1.92	2.06

Charts showing the distribution of pressure at 8 a. m. July 7, 1923, and the area of heaviest rainfall are given on next page.

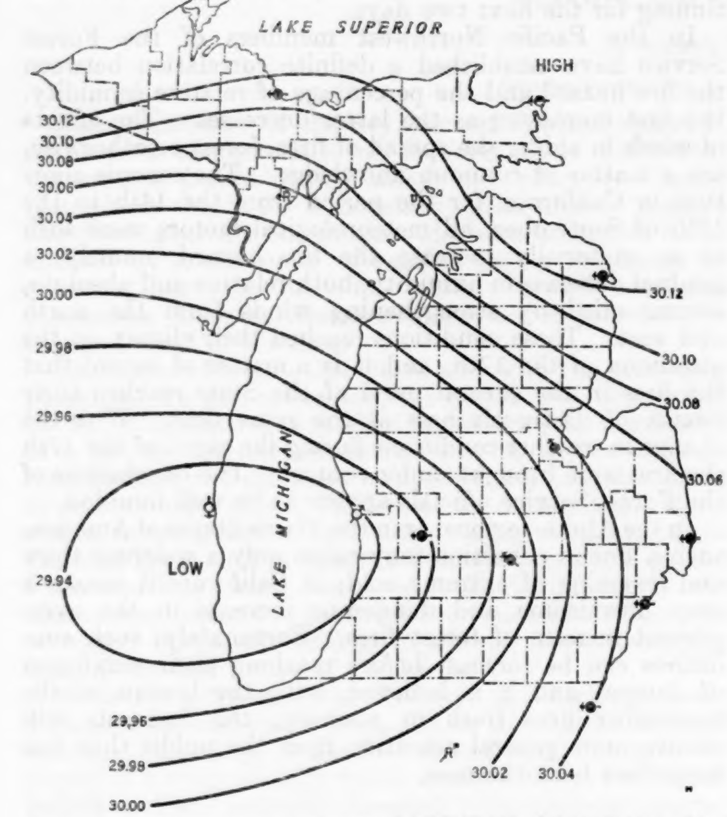

FIG. 1.—Sea-level distribution of barometric pressure over Michigan, July 7, 1923, 8 a. m., 75th meridian time.

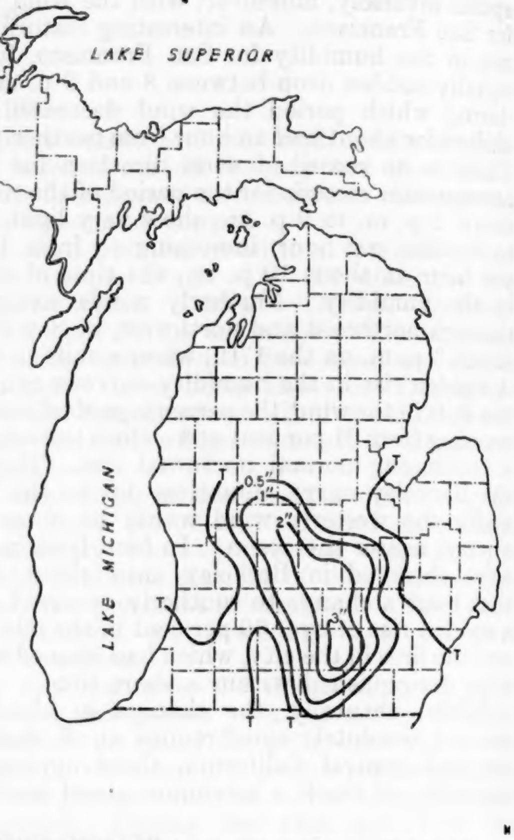

FIG. 2.—Distribution of heavy rainfall in southern Michigan, July 7, 1923.

TORNADO AT COUNCIL BLUFFS, IOWA, SEPTEMBER 28, 1923.

By M. V. ROBINS, Meteorologist.

[Weather Bureau Office, Omaha, Nebr., Oct. 5, 1923.]

On Friday night, September 28, 1923, a small tornado occurred in the southeastern part of Council Bluffs, Iowa, across the Missouri River from Omaha, Nebr. The storm struck about 7:50 p. m., and owing to darkness and a torrential rain but few people saw the cloud. One man whose house stands at the top of a steep hill overlooking the area of worst damage said: "It was a long funnel-shaped cloud with a black column extending from the ground high into the air. I heard it roaring as it swept this way and I and my family rushed into the basement. When we emerged several minutes later we found a large tree down in our back yard almost blocking the door. Trees were uprooted and sheds blown down all around the neighborhood." Another man reported what he saw resembled a ball of fire. Opinions differ as to the sound accompanying the tornado, some saying there was a roar and others that it was like steam escaping from an engine, and it is probable that the metallic roar frequently heard was dulled to a considerable extent by the almost constant thunder and the drumming of the rain.

The cloud moved from the south, especially over that part of the path where most of the destruction occurred; this was confined largely to one street to the east of which is a bluff about 200 feet high and running about due north and south. The path was narrow, a few hundred feet, and probably not to exceed 3 miles in length, but part of which was settled, so the damaged area is but a few blocks long. After the storm passed through this territory it continued over the hills for a short distance, uprooting or breaking some trees and finally dissipated.

The damage done by the tornado was less than anticipated at first, and probably does not exceed $15,000; one house was demolished and a considerable number damaged to a varying extent, but the buildings were mostly small and some were in a poor condition already.

Débris was thrown in all directions, but the trees observed were mostly torn out by the roots and were lying in a northerly direction or toward the northeast. A few roofs were torn off or partly so, one showing the part away from the direction of approach completely gone while that on the south remained almost intact, showing the explosive action of the vortex.

The greatest damage suffered by the city of Council Bluffs was from the excessive rainfall (a fall of 3.04 inches was recorded in two hours, and 6.80 inches in 24 hours at Omaha). Hundreds of people were driven from their homes in the lower sections, and even many business houses and stores were flooded and the floors covered with mud and water. Mud from the hills covered lower Broadway and some other streets for blocks, in places to a depth of more than a foot. Hundreds of homes had their basements filled with water and scores had their first floors covered with water and mud. It is the worst flood since the memorable one of the spring of 1881, which was due to high water in the Missouri River and came in from the low lands up to the higher sections, while this came from the hills and higher ground.

At the Weather Bureau office in Omaha, about 7 miles in an air line from the devastated area, during the passing of the tornado nothing unusual occurred other than a severe thunderstorm. Rain fell at an excessive rate. The barogram shows no more marked fluctuations than frequently occur in ordinary thunderstorms. The wind reached a maximum velocity of 36 miles an hour from the north at 8:04 p. m.

NOTES, ABSTRACTS, AND REVIEWS.

THE INTERNATIONAL METEOROLOGICAL CONFERENCE AT UTRECHT.

[Reprinted from *Nature* (London), October 6, 1923, pp. 523-525.]

Since the first steps were taken in 1853 toward international cooperation in meteorology, the International Meteorological Organization has had a varied career, its meetings sometimes taking the form of congresses of plenipotentiaries appointed by Governments and convened through diplomatic channels, and sometimes of conferences of directors of meteorological services and observatories meeting without official aid.

Until 1919 the organization had no written constitution, but at the first conference held after the war, at Paris in 1919, "règlement de l'organisation météorologique internationale" was formally adopted. According to these rules the International Meteorological Organization comprises: (1) Conferences of directors; (2) the international meteorological committee; (3) commissions. The conferences are to meet every six years and to consist of "all heads of Réseaux of stations in each country and the directors of meteorological observatories which are official and independent of one another," to whom are added a number of directors of private institutes and representatives of meteorological societies.

The international meteorological committee is appointed by each conference to act until the meeting of the next conference, and is to all intents and purposes the executive body of the conference, for it carries out the decisions of the past conference and prepares the business of the next. Each member of the committee must belong to a separate country and must be the director of an independent meteorological establishment. Commissions are appointed by the committee "to advance the study of special questions," and members are appointed simply from the point of view of their personal qualifications to assist the work of the commission. In this way the assistance of men of science and private gentlemen unassociated with official services is made available and freely used.

When the conference met in Paris in 1919 the political state of the world was so abnormal that invitations could not be sent to some countries, and many other countries were not able to be represented. It was, therefore, felt that another conference should be called as soon as conditions became more favorable and all countries without exception could meet in council. When the international meteorological committee met in London in 1921 it was considered that such a time was rapidly approaching, and the invitation of Professor van Everdingen, director of the De Bilt Observatory, Holland, for a meeting of the conference in Utrecht during 1923 was accepted. The return to normal political relationship has not been so rapid as was expected, and the troubles of the early months of 1923 made it look at one time as if the conference would have to be postponed, but it was finally decided not to cancel the invitations which had been dispatched in December, 1922, and this course has been justified by the successful meetings of the conference held in Utrecht on September 7-14.

The meetings of the conference were preceded and followed by meetings of several commissions. The commissions for agricultural meteorology, solar radiation, terrestrial magnetism, and atmospheric electricity, weather telegraphy and maritime meteorology were held before the conference (September 3-6), and the commission for the study of clouds and the commission for the upper air met after the conference (September 14). For the meetings of the commissions and conference 50 members were present, from Argentina (1), Austria (1), Belgium (2), Brazil (1), Denmark (1), Spain (2), Finland (1), France (5), Great Britain (5), India (1), Japan (4), Norway (3), Holland (11), Poland (2), Portugal (1), Russia (2), Sweden (3), Switzerland (2), Czechoslovakia (2).

At the first meeting of the conference on Friday, September 7, Sir Napier Shaw (Great Britain) was elected president, and Doctor Hesselberg (Norway) secretary-general. After the president's address had been delivered and certain business matters disposed of, it was decided to remit all reports and resolutions submitted to the conference to five subcommissions for preliminary consideration and the preparation of suitable recommendations. This distribution occupied the greater part of the meeting on Friday afternoon, when the conference adjourned until the following Tuesday to give the commissions time to prepare their reports. When the conference reassembled on Tuesday it worked very hard for three days considering the sixty-odd resolutions submitted for its approval.

The great development of the use of wireless telegraphy in the dissemination of meteorological data has necessitated very intricate cooperation between meteorological services all over the world, especially in Europe. As the information is distributed broadcast for the use of any one who cares to receive it, it is highly desirable that the messages issued in the various countries should be of the same form and in the same code. As the result of untiring work of the weather telegraphy commission under the guidance of its energetic president, Lieutenant Colonel Gold, the New International Code is now used by 22 meteorological services. The arrangement of the times of issue of the wireless messages to prevent interference is also a difficult matter and necessitates close cooperation. It is not surprising, therefore, that 20 resolutions were submitted to the conference by the weather telegraphy commission. These dealt with such questions as the wording and interpretation of the code, times of issue, description of the stations, reduction of pressure to sea level, additional observations, and the establishment of subcommissions to watch the working of the code and to study proposals for improvements. A new departure was the agreement to add a new group of figures to certain messages, to allow experiments to be made of a new method of forecasting, based on a close study of cloud forms, which has recently been developed by the French Meteorological Office. It was very gratifying that it was not found necessary to alter the International Code, for it is extremely difficult to carry through a change when so many services are concerned, and it would jeopardize all the progress made toward the use of a uniform message if changes were made by some and not by others.

The resolutions submitted by the commission for maritime meteorology were less numerous, but they contained references to several remarkable advances toward the extension of synoptic methods to ships at sea. The commission recommended the adoption of a code to be used for wireless weather messages sent out from ships. The code consists of eight groups of figures, the first four of which are called universal groups and will be the same for all ships in all parts of the world; the second four, called national groups, will be different

according to the office which organizes the issue, and will be designed to meet the different needs of the various services. This proposal, which was accepted by the conference, marks a great advance in international cooperation in all parts of the world. The conference also recorded its appreciation of the work performed on board the *Jacques Cartier*. This is a French ship which has made experiments during voyages between America and Europe of collecting meteorological information by wireless telegraphy from ships and shore, preparing a meteorological chart of the Atlantic, and then broadcasting forecasts for the use of ships. The *Jacques Cartier* carries an officer of the mercantile marine trained in the French Meteorological Office, who is assisted by a clerk lent by that office. Further developments along these lines are to be expected.

The power of the method of "correlation" when applied to meteorological data is now generally recognized by meteorologists. The success of Dr. G. T. Walker, who employs this method in his forecasts of the Indian monsoon, is well known. Such work, however, fails unless homogeneous data extending over a long period are available. Professor Exner, of Vienna, brought this matter before the conference, and a resolution was adopted expressing the opinion that the publication of long and homogeneous data from a number of stations at distances of about 500 or 1,000 kilometers from one another would be of great value. Not content with expressing this opinion, the conference asked Dr. G. T. Walker to supervise the working of the resolution so far as Asia is concerned, and similarly Prof. F. M. Exner for Europe, Mr. H. H. Clayton for America, and Dr. G. C. Simpson for Africa, Australia, and the ocean generally.

The conference was unable to solve the problem submitted to it by the commission for the upper air regarding the international publication of upper-air data. That these data should be collected and published in a uniform manner is highly desirable, but all the efforts of Sir Napier Shaw, the president of the commission, to find a possible way of doing so have been unavailing. Such an undertaking would be expensive and would require financial aid from all countries concerned. In present circumstances it is not surprising that such aid is not forthcoming, and all the conference could do was to make suggestions for meeting temporarily the pressing need for the rapid circulation of results obtained by means of sounding balloons. The data obtained by the use of airplanes and pilot balloons are too numerous to be handled internationally at present, and the conference therefore recommended that each country should publish its own data.

Many resolutions dealing with agricultural meteorology, terrestrial magnetism, atmospheric electricity, solar radiation, and the upper atmosphere were adopted but space does not allow of further details here.

One of the most important questions dealt with by the conference was its relationship to the International Union of Geodesy and Geophysics. The great growth of the official weather services of all civilized countries has provided so many questions of administration and organization for international consideration, that this side of the activities of the International Meteorological Organization has swamped the scientific side. At recent meetings of the conference and committee there has been no time for scientific discussion, and therefore little to attract the members of the organization other than those connected with the great official meteorological services. A resolution was therefore considered to alter the rules in such a way as to limit membership of the conference to directors of meteorological services. There was practically no opposition, and the rule governing the membership of the conference now reads as follows:

"The officers of the committee shall invite to the conference all heads of Réseaux of stations in each country which are official (d'état) and independent of one another."

It was generally understood that this would remove from the work of the organization all questions of pure science, and that the science of meteorology would be considered only in so far as it is applied to the needs of the meteorological services. Practically, this is no change in the work of the organization, but it makes a clear distinction between the sphere of the International Union of Geodesy and Geophysics and the sphere of the International Meteorological Organization. There should now be no material overlap between the work of the union, which considers meteorology from the scientific side, and the work of the organization, which "studies only those questions which are of interest to all national meteorological services and which necessitate the utilization of their own network of stations."

At the last meeting of the conference, when the new international meteorological committee had been elected and Sir Napier Shaw was about to terminate his long connection with international meteorology, Colonel Delcambre, the head of the French Meteorological Office, rose and in a short eloquent speech expressed the regard every member of the conference left for Sir Napier Shaw and the debt which meteorology owed to him. He then proposed that Sir Napier should be elected an honorary member of the international meteorological committee, an honor never before bestowed. The proposal was accepted with prolonged applause and much feeling, for all felt that this was a happy way of marking their appreciation of the great work done by Sir Napier Shaw for international meteorology.

The newly elected committee met the next day and appointed Professor van Everdingen president, and Doctor Hesselberg secretary. The office of vice president was left vacant for the present.

The general feeling at the end of the meetings, frequently expressed, was that good work had been done and much progress made. Good feeling between members from all countries was very marked throughout.

THE EAST-WEST OSCILLATION OF THE ICELANDIC MINIMUM.

By C. E. P. Brooks, M. Sc.

[Abstracted from *Meteorological Magazine*, 174*, No. 692, September, 1923.]

The author has made an examination of 528 pressure charts especially drawn for the study and bases his conclusions upon the evidence of these charts. The charts were examined for cases of an extreme westerly position of the Icelandic minimum, say over Davis Strait and an extreme easterly position in which the minimum was centered over or to the east of Iceland. A scale of marking was adopted to show the position of the minimum for each month. As the work developed the month as a time unit was discarded in favor of overlapping means of 4 months. Plotting the scale values thus obtained the author found evidence of 43 complete oscillations with an average length of 12.1 months. The number of intervals between successive easterly and successive

westerly maxima were 86 and these were distributed as follows:

Length in months.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Frequency.	3	3	1	7	8	8	11	13	7	3	5	4	6	1	2	2	2

There is in the above tabulation a well-marked crest at 11 to 12 months and a secondary crest at 15 to 17 months. The author believes the minimum at 14 months may have been accidental.

After eliminating the annual variation, a tendency for easterly or westerly maxima to recur at the same season in successive years is found. Thus from 1873 to 1883 the chief easterly maxima fell mainly between August and December and the westerly maxima between January and April and the same applies to the years 1889–1896, although the cycle in those years was not well pronounced. On the other hand, easterly maxima generally occurred in the early months and the westerly maxima in the later months from 1884 to 1888, 1897 to 1902, and 1910 to 1916.

Thus there seems to have been a more or less regular recurrence of the same phase of the cycle at about the same time in successive years, alternating with almost complete reversals.

The author suggests some form of seasonal control to account for this.

Earlier investigators of the subject, Meinardus [1] and Petersen,[2] developed the hypothesis of a "self-regulating mechanism" which depends for its operation upon the influence of the wind upon the flow of the warm Gulf Stream waters on the one hand and the cold waters of the Labrador Current on the other.

The time relation is too indefinite and the length of the period required to complete the cycle too variable for use in forecasting.—*A. J. H.*

[1] Meinardus, W.: Der Zusammenhang des Winterklimas im Mittel und Nordwest Europas mit dem Golfström. *Zs. Ges. Erdkunde*, Berlin, 1898, p. 95.

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ON THE FORMATION OF LOCAL DEPRESSIONS IN THE MEDITERRANEAN.

By E. G. MARIOLOPOULOS.

[Abstracted from *Comptes Rendus*, (Paris Acad.), October 1, 1923, pp. 597-600.]

Two types of barometric depression are distinguished in the Mediterranean region, those which are formed locally and those which are related to "families" of moving cyclones of the Northern Hemisphere. The first are usually of slight intensity and move very slowly, while the second type are usually intense and definitely related to the barometric activity over the Atlantic. The local depressions of the Mediterranean region show a line of temperature discontinuity in accordance with the Bjerknesian scheme of cyclonic structure. Temperatures in the cold portion are not uniform, but in the warm portion they are remarkably uniform. The author believes that actual "polar" and "equatorial" air are not essential to cyclonic formation, but that sufficient temperature inequality in opposing air currents can be produced by two adjacent anticyclones, in which case a depression is produced between them. The strong winter anticyclones of Asia and of the Atlantic provide opposing winds of contrasting temperature, which appear to cause the local depressions between them. In summer, when these anticyclones are not so strong and are differently located, such depressions do not form.—*C. L. M.*

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RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Meteorologist in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American meteorological society. Bulletin. Worcester, Mass. v. 4. August–September, 1923.

Brooks, Charles F. Some undesirable climatic features of the shores of small lakes. p. 125–127.

American review of reviews. New York. v. 68. October, 1923.

Woolard, Edgar W. The Japanese earthquake. p. 371–382.

Annales de géographie. Paris. 32 anneé. 15 septembre 1923.

Koláček, F. Les tremblements de terre en Tchécoslovaquie. p. 464–466.

Association of American geographers. Annals. New York. v. 13. June, 1923.

Kincer, Joseph B. The climate of the Great Plains as a factor in their utilization. p. 67–80.

Astronomie. Paris. 37 année. Septembre 1923.

Besson, Louis. L'anthélie, les paranthélies et les halos blancs. p. 371–384.

Dufay, Jean. Le spectre du ciel nocturne. p. 384–386.

Aviation. New York. v. 15. October 8, 1923.

Colvin, Charles H. Calculating altitudes for record purposes. p. 440.

Brazil, Directoria de meteorologia. Revista mensal de meteorologia. Rio de Janeiro. v. 1. 1922.

Giovannini, H. Reducção da pressão barometrica ao nivel do mar. p. 44–46. (Setembro & outubro.)

Medeiros, Renato. O molusco aruá e a previsão de enchentes. p. 49–50. (Setembro & outubro.)

Sampaio Ferraz, [Joaquim de]. A cultura do algodão no Brasil, sob o ponto de vista climatico. Memoria apresentada á Conferencia internacional algodoeira de 1922. p. 3–8. (Setembro & outubro.)

Sampaio Ferraz, [Joaquim de]. Primeiras determinações da espessura da brisa da tarde no Rio de Janeiro. p. 47–48. (Setembro & outubro.)

Silva, Herminio. Observação das nuvens. Um novo instrumento meteorologico. p. 18–21. (Setembro & outubro.)

Silva, Herminio. Sondagem atmospherica por balão piloto. p. 9–17. (Setembro & outubro.)

Silva, Herminio. Applicacções da meteorologia. p. 18–22. (Novembro & dezembro.)

Silva, Moacir. Proverbios meteoro-agricolas (weather lore). p. 51–56. (Setembro & outubro.)

Ciel et terre. Bruxelles. 39. année. Septembre 1923.

Collard, Aug. Silhouettes d'astronomes contemporains. III. Knut Ångstrom. (1857–1910.) p. 210–215.

Nodon, Albert. Les ultraradiations solaires et la radioactivité. p. 204–209.

Discovery. London. v. 4. October, 1923.

James, R. W. Antarctic pack-ice and the fate of the "Endurance." p. 260–265.

Ecology. Brooklyn, N. Y. v. 4. October, 1923.

DeForest, H. Rainfall interception by plants: An experimental note. p. 417–419.

France. Académie des sciences. Comptes rendus. Paris. t. 177. 1923.

Villard, P. Sur la couleur propre des nuages. p. 515–518. (17 sept.)

Guébhard, Adrien. À propos du macrosisme japonais. p. 593–595. (1 oct.)

France. Académie des sciences. Comptes rendus. Paris. t. 177. 1923—Continued.

Mariolopoulos, E. G. Sur la formation des dépressions locales mediterraneenes et la théorie norvégienne du "polar front." p. 597–600. (1 oct.) [Abst. in this REVIEW, p. 469.]

Rothé, E. Sur les tremblements de terre de France en 1920–1921. p. 595–597. (1 oct.)

Franklin institute. Journal. Philadelphia. v. 196. 1923.

Power, A. D. The coefficient of recombination of the natural ions in air, and allied phenomena associated with weak atmospheric ionization. p. 327–352. (Sept.)

Loeb, Leonard B. The absolute mobilities of negative ions in air. p. 537–546. (Oct.)

Geographical review. New York. v. 13. October, 1923.

Montessus de Ballore, Count F. de. p. 633. [Obituary.]

Ward, Robert DeC. Fog in the United States. p. 576–582.

Geographische Zeitschrift. Leipzig. 29. Jahrg. 3. H. 1923.

Greim, Georg. Siegmund Günther. p. 161–164. [Obituary.]

Great Britain. Meteorological office. Geophysical memoirs. London. No. 21. 1923.

Watson, R. E. Pyrheliometer comparisons at Kew Observatory, Richmond, and their bearing on data published in the Geophysical journal.

Heating and ventilating magazine. New York. v. 20. October, 1923.

O'Connor, G. J. Moisture indoors and out. Information which may be passed on to advantage to the prospective user of humidifying equipment. p. 54–55.

Hemel en dampkring. Den Haag. 21 jaarg. 1923.

Gallé, P. H. De abnormale hitte in de eerste helft van Juli 1923. p. 277–280. (Sept.)

Kamerling, Z. Jaren met abnormale weersgesteldheid. p. 193–202. (Juli.) p. 270–277. (Sept.)

India. Meteorological department. Memoirs. Calcutta. v. 23, pt. 6. 1923.

Mossman, R. C. On Indian monsoon rainfall in relation to South American weather 1875–1914.

Japan. Central meteorological observatory. Seismological bulletin. Tokyo. v. 1. March, 1923.

Nakano, Horishi. Notes on the nature of the forces which give rise to the earthquake motions. p. 92–120.

Seismological observations in Tokyo. (September-December 1922). p. 73–91.

Literary digest. New York. v. 79. October 20, 1923.

Trees in an ice-storm. p. 26–27. [Abstr. from Wisconsin magazine.]

National academy of sciences. Proceedings. Washington, D. C. v. 9. October, 1923.

Abbot, C. G. Preliminary note. On the variations of the sun's visible features associated with variations of solar radiation. p. 355–357.

Naturwissenschaften. Berlin. 9 Jahrg. 8 Juli 1921.

Fischer, Karl. Beziehungen zwischen Niederschlag, Abfluss und Verdunstung in Mitteleuropa und einige damit zusammenhängende Aufgaben. p. 533–534. [Abstract.]

Scientific American. New York. November, 1923.

Woolard, Edgar W. Earthquakes and volcanoes. The mechanics of these titanic subterranean forces and their destructive careers. p. 304–305; 370.

Seismological society of America. Bulletin. Stanford University. v. 13. March, 1923.

Willis, Bailey. A fault map of California. p. 1–12.

South African irrigation department magazine. Pretoria. v. 2. July, 1923.

Stewart, C. Notes on the rainfall over the South-West Cape, with special reference to the Berg River. p. 140–148.

U. S. Air service. Washington, D. C. v. 8. September, 1923.

Gregg, Willis Ray. The wind factor in flight: an analysis of one year's record of the air mail. p. 15–17. [Abstract from Mo. weather rev.]

SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1923.

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225, and a note in the REVIEW for November, 1922, **50**:595.

From Table 1 it is seen that solar-radiation intensities averaged slightly below normal values for September at Washington, D. C., and close to normal at Madison, Wis., and Lincoln, Nebr.

Table 2 shows a slight deficiency in the total radiation received on a horizontal surface at all three stations.

Skylight polarization measurements obtained at Washington on five days give a mean of 57 per cent, with a maximum of 71 per cent on the 10th. At Madison, measurements obtained on two days give a mean of 65 per cent, with a maximum of 71 per cent on the 21st. These are slightly below average values for September at Madison, and close to September averages at Washington.

During the month, comparative readings were obtained between Smithsonian Silver Disk pyrheliometer No. 1, and Marvin Silver Disk pyrheliometers No. V and No. VI. These two latter instruments have been in continuous use at Madison, Wis., and Lincoln, Nebr., respectively, since June, 1918. It is gratifying to be able to state that their readings are still in accord with the Smithsonian revised pyrheliometric scale within ±1 per cent.

TABLE 1.—*Solar radiation intensities during September, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th mer. time.	Air mass.									Local mean solar time.
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Washington D. C.											
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 10	9.83	0.63	0.76	0.93	1.15	1.48	1.10	0.60	......	......	8.18
12	13.13	......	......	......	0.82	1.15	......	......	......	......	15.11
14	6.02	......	......	......	......	1.42	1.18	0.90	0.73	0.61	5.79
16	6.27	......	0.59	0.73	0.95	1.27	0.99	0.78	0.64	......	4.95
17	6.27	0.50	0.63	0.80	1.04	......	0.90	0.66	......	......	6.50
24	17.37	......	......	......	......	1.18	......	......	......	......	16.20
25	15.65	......	......	......	0.51	......	......	......	0.33	......	16.20
Means	......	(0.56)	0.66	0.82	0.89	1.30	1.04	0.74	0.57	(0.61)	......
Departures	......	−0.08	−0.06	−0.05	−0.15	−0.01	−0.01	−0.11	−0.15	−0.04	......

*Extrapolated.

TABLE 1.—*Solar radiation intensities during September, 1923*—Contd.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th mer. time.	Air mass.									Local mean solar time.
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Madison, Wisconsin.											
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 5	15.11	......	......	......	......	1.11	......	......	......	......	16.79
8	8.81	......	......	......	1.28	......	......	......	......	......	7.87
10	7.57	......	......	1.06	1.16	......	......	......	......	......	9.47
13	4.37	......	......	......	1.31	......	......	......	......	......	4.57
21	8.48	......	......	......	1.32	1.45	......	......	......	......	8.81
Means	......	......	......	(1.06)	1.27	(1.28)	......	......	......	......	......
Departures	......	......	......	+0.04	+0.10	−0.09	......	......	......	......	......
Lincoln, Nebr.											
Sept. 3	13.13	......	0.81	0.95	1.14	......	......	......	......	......	12.24
4	12.24	......	0.70	0.85	1.00	1.23	......	......	......	......	10.59
5	13.61	0.59	0.71	0.86	1.07	1.29	......	......	......	......	14.60
7	7.04	......	0.97	1.11	1.28	1.48	......	......	......	......	5.16
8	6.27	0.87	0.95	1.06	1.26	1.43	1.22	1.05	0.93	0.83	7.57
9	7.87	0.81	0.92	1.06	1.23	1.46	1.21	1.03	0.87	0.77	7.57
12	7.29	......	0.93	1.07	1.22	......	......	......	......	......	6.76
13	7.29	......	......	......	......	......	1.16	1.02	0.87	0.76	6.02
21	8.18	......	......	0.91	1.07	......	......	......	......	......	8.48
29	13.61	......	......	......	......	......	1.03	......	......	......	17.37
30	12.24	......	......	......	......	1.41	......	......	......	......	13.61
Means	......	0.76	0.86	0.98	1.16	1.38	1.16	1.03	0.89	0.79	......
Departures	......	+0.01	+0.01	−0.02	−0.02	−0.01	−0.02	+0.06	+0.06	+0.06	......

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	279	342	534	−117	−35	+96	−4,011	−226	−1,266
10	423	368	359	+43	+17	−54	−3,740	−110	−1,643
17	257	254	311	−108	−74	−82	−4,498	−625	−2,215
24	376	260	311	+27	−46	−64	−4,309	−325	−2,661

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The following figures show the average monthly pressure at 8 a. m., 75th meridian time, together with approximate departures, at a number of selected land stations on the coast and islands of the North Atlantic Ocean. The barometric readings are in inches and the normals were taken from the Pilot Charts.

St. Johns, Newfoundland, average, 30.04, departure, +0.04; Nantucket, 30.11, +0.06; Hatteras, 30.08, +0.04; Key West, 29.97, +0.02; New Orleans, 30.02, +0.04; Swan Island, 29.88, ±0.00; Turks Island, 30.02, +0.04; Bermuda, 30.09, +0.03; Horta, Azores, 30.25, +0.09; Lerwick, Shetland Islands, 29.69, −0.14; Valentia, Ireland, 29.99, ±0.00; London, 30.00, ±0.00.

At Horta the average pressure for the first 20 days was considerably higher than for the last decade of the month, the average barometric reading for the former period being 30.32 inches and for the latter 30.10 inches.

The number of days with winds of gale force was not far from the normal over the middle division of the steamer lanes. Stormy weather was more prevalent than usual between the 30th meridian and the European coast, and also in the western section of the ocean, due primarily to the tropical disturbance that occurred in the latter part of the month.

The number of days with fog was considerably above the normal over the Grand Banks and off the American coast, and fog was also observed more frequently than usual over the middle and eastern sections of the steamer lanes.

From the 3d to the 6th the Icelandic LOW was unusually active, and on the 4th moderate westerly gales prevailed over the region between the 50th and 60th parallels and the 20th and 35th meridians.

On the 4th and 5th a comparatively severe disturbance, though limited in area, appeared in the vicinity of the Bermudas. Storm log:

American S. S. *Evergreen City:*

Gale began on the 5th, wind ESE., 6. Lowest barometer 29.32 inches at 1:40 a. m. on the 5th, wind NE., 10, in latitude 36° N., longitude 61° W. End on the 6th, wind NW. Highest force of wind 10, NE.; shifts ESE–E–NE.

On the 6th, according to reports received, moderate weather was the rule over the western section of the ocean, while a few vessels east of the 30th meridian reported moderate gales.

On the 7th and 8th there was an area of low pressure, central near latitude 40°, longitude 60°, and a few vessels reported northerly to easterly gales; by the 9th it had moved slightly northward, and deepened considerably. Storm logs:

British cable S. S. *Faraday:*

Gale began on the 6th, wind NE. Lowest barometer, 29.82 inches at 5 a. m. on the 9th, wind NNE., 5, in latitude 40° 18′ N., longitude 63° 30′ W. End on the 9th, wind N. Highest force of wind 8, NE.; shifts not given.

American S. S. *Mount Evans:*

Gale began on the 8th, wind S. Lowest barometer 29.57 inches at midnight on the 8th, wind S., 10, in latitude 39° 30′ N., longitude 56° 40′ W. End on the 9th. Highest force of wind 10; shifts S–SW.

On the 9th westerly gales also prevailed off the north coast of Scotland, although, according to reports received, they were not very severe.

At the time of the Greenwich mean noon observation on the 12th, moderate conditions apparently prevailed over the entire ocean. Later in the day, however, a severe storm of short duration appeared, as shown by the following storm logs.

American S. S. *Emergency Aid:*

Gale began on the 11th, wind SE. Lowest barometer 29.45 inches at 2 p. m. on the 12th, wind SW., 11, in latitude 36° N., longitude 64° 40′ W. End on the 12th, wind W. Highest force of wind 11, SW.; shifts SE. to WSW.

American S. S. *City of St. Joseph:*

Gale began on the 12th, wind ESE. Lowest barometer 29.11 inches at 6 p. m. on the 12, wind NW., 12, in latitude 42° 04′ N., longitude 61° 43′ W. End on the 12th, wind NW. Highest force of wind 12, NW.; shifts ESE.–NW.

A waterspout was seen on the 12th. Report follows.

British S. S. *Nessian:*

On Wednesday, September 12 at 1:55 p. m. L. M. T., in latitude 25° 34′ N., longitude 76° 40′ W., two waterspouts very close together, one about 500 feet high and the other about 80 feet. They both retained their altitude for seven minutes and then collapsed.

On the 14th and 15th the waters adjacent to the west coast of Scotland were visited by a severe disturbance. Storm log:

Danish S. S. *United States:*

Gale began on the 14th, wind N. Lowest barometer 29.21 inches at 3 p. m. on the 15th, wind NNE., 8, in latitude 58° 27′ N., longitude 6° 55′ W. End on the 15th, wind NNE. Highest force of wind 10, N.; shifts N.–NNE.

On the evening of the 16th the British S. S. *Almagro*, when a short distance east of Charleston, S. C., encountered a moderate easterly gale that afterwards increased in intensity. Her storm log is as follows:

Gale began on the 16th, wind SE. Lowest barometer 30.09 inches at midnight on the 16th, wind SE., in latitude 27° 53′ N., longitude 79° 32′ W. End on the 17th, wind NNE. Highest force of wind 10. The wind backed from SE. to NNE. with barometer rising from beginning to end of storm.

This disturbance was apparently of very limited extent and short duration, and comparatively high barometric readings were recorded in the vicinity at the time of observation on the 16 and 17th.

On the 17th the center of a deep depression was near the northwest coast of Scotland and strong gales prevailed over the territory between the 45th and 60th parallels, east of the 30th meridian. This LOW moved slowly eastward during the next 24 hours and by the 18th the center was near Aberdeen, Scotland, while the storm area had contracted in extent and the wind decreased in force. Storm logs:

German S. S. *Westphalia:*

Gale began on the 16th, wind SW. Lowest barometer 29.51 inches at 5 a. m. on the 17th, wind NW., 11, in latitude 49° 52′ N., longitude 17° 09′ W. End on the 17th, wind WNW. Highest force of wind 11, NW.; shifts W.–NW.–WNW.

British S. S. *Saxonia:*

Gale began on the 16th, wind W. Lowest barometer 29.90 inches at 4 a. m. on the 17th, wind NNW., in latitude 49° 06′ N., longitude 25° 39′ W. End on the 18th, wind NW. Highest force of wind 9, NW.; shifts NNW.–NW.

On the 19th a fairly well developed LOW was central near latitude 45°, longitude 45°. This apparently moved rapidly northward, as it did not appear within the limits of the map on the 20th.

From the 21st to the 26th moderate to strong gales prevailed over the eastern section of the steamer lanes,

the storm area expanding and contracting from day to day. On the 24th a second LOW was central near latitude 53°, longitude 47°, and the two storm areas practically met in mid-ocean.

Dutch S. S. *Newyork:*

Gale began on the 22d, wind W. Lowest barometer 29.54 inches at 6 p. m. on the 23d, wind W., in latitude 50° N., longitude 20° 13′ W. End on the 24th, wind W. Highest force of wind 8; shifts S.-SW.-W.

British S. S. *Parthenia:*

Gale began on the 24th, wind WSW. Lowest barometer 29.20 inches at 10:30 a. m. on the 24th, wind W., 10, in latitude 52° 27′ N., longitude 47° 58′ W. End on the 25th, wind NNW. Highest force of wind 11; shifts WSW.-NW.-NNW.

British S. S. *Samaria:*

Gale began on the 24th, wind S. Lowest barometer 28.97 inches on the 24th, wind W., 10, in latitude 51° 05′ N., longitude 17° 11′ W. End on the 25th, wind W. Highest force of wind 10; shifts WSW.-W.

Charts VIII to XII show the daily conditions prevailing from the 26th to the 30th, inclusive. It was during this period that the tropical disturbance, previously referred to, prevailed. A report of this hurricane will be found elsewhere in the REVIEW, but several gale reports from vessels involved are given herewith:

American S. S. *Hera:*

Gale began on the 26th, wind SSE. Lowest barometer 29.34 inches at 10 a. m. on the 26th, wind SSE., 5, in latitude 28° 30′ N., longitude 71° 45′ W. End on the 27th, wind S. Highest force of wind 10, SSW.; shifts SSE.-S.

American S. S. *Currier:*

Gale began on the 26th, wind ENE., 7. Lowest barometer 29.56 inches at 9 a. m. on the 27th, wind NE., in latitude 29° 35′ N., longitude 76° 50′ W. End at 4 p. m. on the 27th, wind NNW. Highest force of wind 10, ENE.; shifts NE. by E.-NE.

British S. S. *Eastern Prince:*

Gale began on the 27th, wind ESE. Lowest barometer 29.46 inches at noon on the 29th, wind N., 10, in latitude 32° 39′ N., longitude 75° 16′ W. End on the 30th, wind SW. Highest force of wind 10, N.; shifts NNE.-N.-NNW.

American S. S. *Afel:*

Gale began on the 28th, wind SSE. Lowest barometer 29.58 inches at 4 p. m. on the 29th, wind SW., in latitude 27° 34′ N., longitude 73° 10′ W. End at 8 a. m. on the 30th, wind NW. Highest force of wind 10; shifts SW.-NW.

British S. S. *Maraval:*

Gale began on the 29th, wind ESE. Lowest barometer 28.98 inches on the 30th, wind ESE., in latitude 34° 49′ N., longitude 70° 39′ W. End on the 30th, wind NW. Highest force of wind 12, NE.; shift 10 points.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

Over a substantial area of the North Pacific Ocean there was no material change in September from the good weather of the preceding month. Over the most frequented northern routes, however, the advent of autumn was manifested in the increased activity of the Aleutian LOW, which resulted in squalls and storm winds of much greater frequency and severity than in August.

For the month as a whole pressure averaged below normal over the eastern part of the ocean, the greatest relative departure occurring at Midway Island. Here the pressure for the month, based on p. m. observations, was 29.93 inches, as compared with the normal of 30.01, or a deficiency of 0.08 inch. The average departure from normal at Midway Island in the month of September for the past 12 years has been 0.04 inch. The highest pressure, 30.08, occurred on the 3d and 31st; the lowest, 29.94, on the 17th. The average pressure at Dutch Harbor, based upon p. m. observations, was 29.68 inches. The normal here for September is 29.75. The highest pressure, 30.54, occurred on the 17th; the lowest 28.54, on the 27th. Absolute range, 2 inches. There were five days in which a. m. or p. m. pressures were below 29 inches. It will be noted that the range in pressure between Midway Island and Dutch Harbor on the p. m. of the 17th was 1.34 inches. At Honolulu the average p. m. pressure was 29.97, or 0.01 below normal. The highest pressure, 30.18, occurred on the 18th; the lowest, 29.82, on the 20th.

About the 18th of the month the northern portion of Bering Sea was swept by severe gales, and several schooners bound for Nome were reported greatly in danger. The p. m. observation at Nome on the 18th showed a pressure of 29.76 inches and a south wind, force 7. Pressure there continued low for several subsequent days.

Along the routes between the Hawaiian Islands and the American mainland the weather was generally good. The North Pacific high-pressure area maintained a fair-to-good development throughout most of the month. Its center for many days was near 45° north latitude, 150° west longitude, thus giving prevailing winds from the east at Honolulu.

On the 16th pressure began falling at Midway Island, and reached its minimum there on the 17th. The p. m. observation of the 17th showed the wind to be of force 6 from the west, pressure 29.24. During these dates a storm was in the vicinity, but it was reported by only one vessel, the American S. S. *Dickenson*, Capt. George Peltz, Midway toward Honolulu. On the 17th this steamer recorded a south wind, force 4, pressure 29.64, in latitude 26° 40′ N., longitude 173° 20′ W.; and on the 18th a south by west wind, force 8, pressure 29.81 inches, in 26° 10′ N., 170° 20′ W. The storm apparently moved northward from Midway, although the subsequent drop in pressure at Honolulu on the 20th might be taken as an indication that the cyclone had spread eastward, diminishing in intensity and vanishing in low latitudes. At Honolulu on the 21st the remarkable phenomenon of thunder was heard in consequence of the unsettled conditions. This is the fourth time in which thunder has been heard in September at this station since its establishment in 1904.

Conditions were generally quiet along the tropical west coast of North America. Vessel reports thus far received indicate no disturbance at sea in the vicinity. A newspaper report, however, tells of a storm which damaged Acapulco, Mexico, on the 23d. There is no indication of this on the weather map.

In the Far East at least two tropical cyclones of great intensity occurred in September. Lack of complete information from the Philippine Islands and of the regular daily observations from Japan, both of which contribute greatly to our knowledge of conditions in this quarter, render it impossible at this writing to announce more than this number, or further regarding the movements of these storms.

During the earthquake which so vitally damaged certain sections of Japan on September 1, it was reported that the horrors of the catastrophe at Yokohama were intensified by the presence of a typhoon. It is true that the remnants of a tropical storm, which had been hovering over the southern portion of the archipelago for two or three days, were still existent. Heavy rain occurred at Yokohama during the early morning, and the winds were moderate to fresh southerly during most of the day,

with the center of the depression slightly to the westward. This brisk south wind undoubtedly fanned considerably the flames of the burning city. The observer on board the British S. S. *Philoctetes* reported in the afternoon that "small local whirlwinds circulating clockwise were created in some parts of the harbor. The water as it followed these whirls was extremely agitated."

During the late hours of the 8th and the early hours of the 9th the Japanese S. S. *Ypres Maru*, Captain Kimura, Observer Yashida, Kobe toward Portland, experienced a typhoon in latitude 39° 30′ N., longitude 147° E. At 1 a. m. of the 9th a hurricane wind from the west was experienced, lowest pressure 28.12 inches (uncorrected).

During the 9th the American S. S. *President McKinley*, Captain Justie, Seattle toward Yokohama, encountered the full blast of this typhoon in latitude 43° 45′ N., longitude 154° 20′ E. Gale winds lasted from 9 a. m. to about 4 p. m., highest force 12, from the SSW., shifting to W., lowest pressure 29.06 inches.

During the period from the 9th to the 15th the American tank S. S. *Broad Arrow*, Capt. J. A. Vanden Heuvel, Observer A. G. Popkin, Hongkong toward San Pedro, was involved either in two typhoons, or, what is perhaps more probable, the same typhoon at different times. To quote:

September 9: At 6 p. m. wind increased to force 7. NNW. Position at 8:08 p. m., latitude 26° 17′ N., longitude 122° E. Wind at midnight had increased to force 8.

September 10: At 1 a. m. wind shifted to NW. by N. 8; at 2:15 a. m. to NW., increasing to force 9 at noon, barometer 29.61; 2:15 p. m. wind increased to force 10, barometer 29.54; 8:15 p. m. position, 26° 50′ N., 123° 20′ E.; 11 p. m. wind increased to force 12, and shifted to W. by N., running into typhoon, barometer 29.16.

September 11: At 1:35 a. m. entered central area of typhoon, wind shifting to SW., force 4, barometer 29.03. At 3 a. m., in 27° 20′ N., 123° 50′ E., passed through center of typhoon—perfectly calm—ship literally covered with bugs and small birds. Barometer 28.92. Remained calm until 5:30 a. m. when wind came from east with force of 10. At 10 a. m. barometer began rising and wind moderating, shifting to E. by N., force 8. At 4 p. m. wind E., force 6, barometer 29.72. Position at 8:20 p. m., 28° 30′ N., 124° 45′ E.

September 13: At 4 p. m. barometer 29.59. wind ENE. 9. Strong gale and increasing to NE. by E., force 10, barometer 29.50 at midnight. Position at 8:48 p. m., 31° 09′ N., 131° 36′ E.

September 14: At 8 a. m. barometer 29.31. Wind NE., blowing typhoon, and lasting until 1 a. m., September 15. Lowest pressure 28.92 inches in latitude 32° 40′ N., longitude 134° 30′ E. Highest wind force NW. 12.

The Dutch S. S. *Arakan*, Capt. J. Hamersma, Observer P. Bubberman, made interesting observations of this storm. The *Arakan* left Nagasaki for Kobe, via Moji, at 5 a. m. of the 12th. Her subsequent experiences are quoted:

Departing from Moji, we saw a typhoon warning hoisted, the typhoon being south of Japan and moving in NNW. direction. After leaving, the barometer fell quickly, while the wind changed from ENE. to NNE., later veering to ENE., increasing to force 9 in the evening of the 14th. During the night of the 13th–14th the barometer kept on falling quickly, wind ENE.–NE., 4 to 5. In the morning of the 14th it began gaining, first a little, then strong. So in the afternoon of the 14th at 4 p. m. we were forced to anchor south of Shodo-Shima, in Sakate Bay, as we could not see anything. Toward midnight the wind decreased a little, but the rain fell down in torrents. The barometer kept on falling, and this in connection with the steady direction of the wind (NNE.), caused us to believe that the center would pass either overhead or very near. At 11 p. m. the wind decreased very suddenly, and the sky cleared overhead, so that we could see the stars shining. * * * The next morning it cleared so far that we could proceed to Kobe, where we anchored at 4 p. m. of the 15th. At 3 p. m. our barometer reached its lowest point, 735.3 mm. (28.95 inches), then began rising quickly.

On September 14 the American tank S. S. *Liebre*, Captain Christensen, Tokuyama, Japan, toward San Pedro, Calif., experienced the storm in approximately latitude 36° 16′ N., longitude 137° E., wind ESE., force 11, pressure 29.28 inches.

This typhoon is reported to have been particularly disastrous to a portion of Japan northwest of Kobe. The rains were extraordinarily heavy, and several small villages were destroyed by floods. Tokio and Yokohama also suffered greatly. Some 5,000 people are said to have lost their lives by drowning on the 13th and 14th.

On the 23d and 24th of the month a disturbance which may have been a typhoon was reported by the American S. S. *West Momentum*, Captain Wennerlund, Nogoya, Japan, toward Portland, Oreg. The first gale was experienced at 10 p. m. of the 23d, wind NNE., force 8. The lowest pressure was 28.92 inches (uncorrected), near 34° 27′ N., 138° 40′ E., on the 24th, highest force of the wind N., 10. Associated with this storm were the gales of forces 7 and 8 encountered by the Japanese S. S. *Tokiwa Maru* from the 22d to the 25th while eastward bound between 36° 30′ N., 142° 40′ E., and 42° 45′ N., 156° 10′ E.

To the eastward of the 180th meridian, as generally observed along the northern steamship routes, the stormy weather which has been previously alluded to did not set in with vigor until after the 20th, although occasional gales occurred of force not exceeding 8, especially near 50° N., 150° W., on the 9th and 10th. On the 21st, however, the cyclone, which had been central for several days in the vicinity of Nome, began traveling inland and southward, and by the 23d was causing rough weather over the Gulf of Alaska and thence along the coast to Vancouver. On this date, in the extreme northern edge of the gulf—59° 52′ N., 149° 28′ W.—the American S. S. *Northwestern* experienced north-northwesterly to north-northeasterly gales rising to force 10, lowest pressure 29.54. In 49° N., 137° 55′ W., the Japanese S. S. *Hakata Maru* experienced a northwesterly gale, force 8, minimum pressure 29.50 inches. In 48° 48′ N., 127° 14′ W., the American S. S. *Crosskeys* reported a southeast gale, force 8, pressure 29.75 inches.

On the 25th this storm had dissipated, but another, central over Alaska, was stirring the waters of the northern gulf and the Aleutian region. The *Northwestern* encountered a southeasterly gale, force 11, pressure 29.18 inches, in 59° N., 142° W. The observer stated:

While in a southeasterly gale off Cape St. Elias, a vessel in latitude 58° 50′ N., longitude 140° W., at 8 p. m. reported: "Weather clear and calm. Clouds coming up from the southeast." Whole gale until a. m. 26th off Cape Spencer, with continuous heavy rain.

From the 26th until the close of the month the primary storm center was over the Aleutians and southwestern Alaska and was causing gales and heavy seas over a large expanse of ocean. The British S. S. *Achilles* reported gales from the 25th when in 49° 57′ N., 172° 08′ W., until late on the 29th, when near 49° 22′ N., 133° W. Her highest recorded wind was SW., 10, on the 27th, lowest pressure 28.85 inches on the 28th. This low reading occurred in 50° 01′ N., 149° 44′ W. The Japanese S. S. *Shidzuoka Maru*, bound for Seattle, experienced gales from the 26th until the 30th over much the same area as in the preceding instance. The highest wind force was 10 from the SSE., lowest pressure 28.76 inches, in 51° 02′ N., 157° 40′ W., on the 28th. Other vessels, all eastward bound, reporting high winds during this period were the Dutch S. S. *Arakan*, with highest wind force 9, SSW., lowest pressure 733 mm. (28.86 inches) uncorrected, in 49° 45′ N., 155° 46′ W., on the 28th; the American S. S. *Broad Arrow*, SW., 9, lowest pressure 29.57 inches, in 42° 19′ N., 155° 05′ W., on the 28th;

the American S. S. *West Keats*, NW., 10, lowest pressure 29.02 inches, in 49° 50′ N., 166° W., on the 28th; and the British S. S. *Tahchee*, SSW., 9, lowest pressure 29.54 inches, in 45° 22′ N., 146° 20′ W. On the 30th the rough weather of the previous week showed signs of abatement.

Fog conditions, as drawn from ships' observations, indicate some slight clearing up since August. Scattered fog, however, occurred all along the northern routes, being particularly frequent to the westward of the 180th meridian. Between the 35th and 40th parallels, off the California coast, fog was reported on 9 days.

NOTE.

The American S. S. *Algonquin*, Capt. W. S. Harriman, Observer J. L. Patton, reports: "September 2, 8:30 p. m., latitude 14° 27′ N., longitude 95° 57′ W. A number of waterspouts to southward."

GALES ON THE SOUTH PACIFIC OCEAN.

By WILLIS E. HURD.

On the 7th and 8th of September, 1923, the British S. S. *Doonholm*, Capt. W. R. S. Branigan, experienced a southwest gale, force 7, lowest pressure 29.47 inches, in latitudes 43° 29′ S., to 42° S., longitudes 155° 20′ E. to 151° E., while on a voyage from Dunedin, New Zealand, toward Melbourne.

On the 8th and 9th of the month the British S. S. *Niagara*, Capt. J. T. Rolls, Sydney toward Auckland, experienced heavy squalls for several hours, near latitude 34° 50′ S., between longitudes 168° and 175° E. The highest force of the wind was 10 from the NE., on the 9th, lowest pressure 29.57 inches.

The British S. S. *Doonholm* again encountered a northwest to southwest storm in latitude 38° S., longitude 145° E., on the 20th. The highest wind force was SW. 10, lowest pressure 29.06.

EIGHT TYPHOONS IN THE FAR EAST DURING AUGUST, 1923.

By Rev. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

There were no less than eight typhoons shown by our weather maps in the Far East during the month of August. Although only two of them traversed the Philippine Islands, yet several others influenced us a great deal in our weather, particularly with heavy rains and floods in the western part of Luzon. The monthly total rainfall for Manila and a few other stations of western Luzon, with the respective difference from the normal of August, will be of interest to our readers.

Stations.	Monthly total.	Difference from normal.
	mm.	*mm.*
Manila	1,147.6	+737.3
Iba	2,401.2	+1,326.8
Dagupan	1,189.3	+636.8
Baguio	2,378.7	+1,133.6
San Fernando Union	1,437.2	+706.1
Vigan	1,151.7	+432.8

The heaviest rains for 24 hours were those of Baguio, 533.4 mm.; San Fernando Union, 394.7 mm., and Iba, 288.7 mm. The heaviest daily rainfall for Manila was 197.4 mm.

The Babuyanes typhoon, August 3.—This typhoon was probably formed on July 29 to 30 to the east of southern Luzon, not far from 128° longitude E. and 13° or 14° latitude N. Its track was somewhat indefinite until 6 a. m. of August 2, when we could situate the center quite approximately in 125° longitude E., between 17° and 18° latitude N. Hence, it moved WNW., passing through the Babuyanes Islands about 40 miles to the north of Aparri in the afternoon of the 3d and entering China to the NE. of Hongkong in the afternoon of the 5th. The approxiate position of the center at 6 a. m. for the period August 3 to 5 was as follows:

August 3, 6 a. m., 122° 35′ longitude E.; 18° 50′ latitude N.

August 4, 6 a. m., 118° 45′ longitude E.; 20° 30′ latitude N.

August 5, 6 a. m., 116° 00′ longitude E.; 22° 15′ latitude N.

The Loochoos and China typhoon, August 3 to 8.—This typhoon was first noticed in our weather maps in the afternoon of the 3d in about 138° longitude E. and 23° latitude N. It moved WNW. toward the Loochoos, the barometer at Naha having fallen at 6 p. m. of the 6th to about 722 mm. Between the Loochoos and China the typhoon inclined westward. The approximate position of the center at 6 a. m. of the 6th to 8th was:

August 6, 6 a. m., 129° 40′ longitude E.; 25° 30′ latitude N.

August 7, 6 a. m., 125° 00′ longitude E.; 27° 20′ latitude N.

August 8, 6 a. m., 119° 15′ longtitude E.; 26° 55′ latitude N.

The Meiacosima and China typhoon, August 8 to 11.—The first part of the track of this typhoon is somewhat uncertain, although it probably formed on August 3 to 4 south of Guam near 145° longitude E. and 10° latitude N., moving northwestward until August 6 and then westward on the 7th and part of the 8th. The center can easily be situated in our weather map of the 8th, 6 a. m., near 130° longitude E., between 18° and 19° latitude N.; and at 6 a. m. of the 9th in about 127° longitude E., between 20° and 21° latitude N. The typhoon was moving then NNW. and so it struck the Meiacosima group of islands about 150 miles east of northern Formosa on the 10th. The station of Ishigakihima reported at 6 a. m. of that day a barometer as low as 722.5 mm. with hurricane winds from the N. From Meiacosima the typhoon inclined northwestward and entered China in the morning of the 11th between 27° and 28° latitude N. Once in China it moved again NNW., gradually recurving to the NE. on the 12th, and traversed Manchuria on the 13th.

The Batanes and Hongkong typhoon, August 17 and 18.—The first part of this typhoon is somewhat uncertain and indefinite, although we are inclined to believe that it is the same as was shown in our weather map at 2 p. m. of the 11th to the SSW. of Guam in about 143° longitude E. and 11° latitude N. If this be the case, we have to suppose that after moving NNW. from the 11th to the 13th, it inclined decidedly to the W. on the 13th and 14th. The center was clearly situated at 6 a. m. of the 16th, between 20° and 21° latitude N. and in about 127° longitude E. It was moving almost due W,

at a rate of near 13 miles per hour. The steamer *Steel Traveler* met the center of this typhoon in 123° 20′ longitude E. and 21° 00′ latitude N., the barometer having fallen on board to 711.2 mm. (28 inches), not corrected for gravity, at 8 p. m. of the 16th and two hours of calm having been observed with a steady barometer. Our observer at Basco (121° 59′ longitude E. and 20° 28′ latitude N.) reported by wireless to this office a barometric minimum as low as 714.50 mm., not corrected for gravity, recorded at 3 a. m. of the 17th with a whole gale backing from NNW. to SW. and S., thus confirming the direction of the typhoon and its rate of progress as given above. As the calm observed on board the *Steel Traveler* lasted for two hours, we suppose that the real center of the typhoon passed over her at about 9 p. m., and hence the rate of progress of the typhoon between this steamer and Basco was about 13.5 miles per hour.

The typhoon after passing near to the north of Basco continued moving westward, increasing its rate of progress to an average of about 15 miles per hour, threatening the English colony of Hongkong. Although proper and timely warnings had been given since August 17, the storm was a great calamity for Hongkong, it being considered the worst experienced there for the last 15 years. And if not for the extraordinary rate of progress of the typhoon the havoc wrought there would have been even much greater. The lowest barometric minimum was 28.66 inches (727.95 mm.); it was recorded at 10 a. m. of the 18th. The highest wind squall velocity registered during the typhoon was 130 miles an hour at 10:13 a. m. of the same day. The center passed near to the south of Hongkong. There were at least four vessels sunk, among them the *Loonsang* and twenty driven ashore. The losses of lives were considerable both afloat and ashore.

The typhoon of the Loochoos and Korea, August 22 to 28.—The first part of this typhoon up to the 22d is still somewhat uncertain with the few observations we have on hand. At 6 a. m. of the 22d the center was situated near 131° longitude E. and 27° latitude N. moving WNW. The center passed near to the south of Oshima on the same day and recurved northeastward on the 24th about 200 miles to the west of Shanghai. It traversed Korea on the 25th and the Sea of Japan on the 26th moving NE.

Other four less important typhoons.—The first of them appeared to the south of Guam on the 15th near 144° longitude E. and 11° latitude N. It moved for a short time NW., then N., and finally E., traversing in this direction the northern part of the Ladrone Islands on the 17th.

The second typhoon formed on the 19th to 20th over the China Sea NW. of Luzon in about 118° longitude E. and 19° latitude N. It moved almost due W., traversing Hainan in the afternoon of the 22d.

The third typhoon appeared also in the China Sea on the 26th in about 116° longitude E., between 19° and 20° latitude N., and moved NNW., passing about 50 miles to the east of Hongkong in the afternoon of the 27th.

The last typhoon of the month appeared almost simultaneously with the preceding one in the Pacific to the SE. of the Loochoos in about 130° longitude E., between 21° and 22° latitude N. It passed through the Loochoos as a depression of little importance in the afternoon of the 27th, but it developed into a real typhoon in the Eastern Sea while recurving northeastward. It moved very slowly, and reached the southwestern part of Japan during the night of August 30 to 31.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

ALFRED J. HENRY.

The outstanding features seem to have been (1) a movement of anticyclones across the Lake region and down the St. Lawrence Valley, and as a consequence a very substantial increase in pressure from the average level of the preceding month; (2) temperature mostly above the normal; (3) greater than normal precipitation in the majority of States. The usual details follow.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

Four disturbances formed within the area between Bermuda and the West Indies and three of these displayed the characteristic central core of the tropical hurricane. However, the only one that could be said to be of tropical origin developed just north of Haiti on the 25th, and though it followed a more or less normal path, it was very much retarded during its recurve by high pressure to the northward, the storm finally moving northeastward with considerable acceleration when released by falling pressure to the northward. Another disturbance developed hurricane characteristics on the 5th when about 300 miles northeast of Bermuda. There were some indications of this disturbance as a depression north of the Lesser Antilles during the last day or so of August. It was followed with more or less uncertainty as it recurved around Bermuda and was first noted as a storm on the 5th, as previously stated. At this time further movement was stopped by rising pressure to the north and northeast and the storm after remaining nearly stationary for two days turned northward with increasing speed as the air-pressure began to fall in that direction.

After this storm passed out of the field of observation northeast of Newfoundland, unsettled conditions continued over the area of the Gulf Stream and by the morning of the 12th another storm, extremely small but very intense, was noted about 250 miles north of Bermuda. This storm moved rapidly northeast to southeastern Newfoundland, having enlarged its area and diminished in intensity upon leaving the warm waters of the Gulf Stream. Full hurricane velocities were reported by vessels encountering this small disturbance.

A fourth disturbance developed to the northeast of the Bahamas on the 14th and 15th of the month, enlarged its area rapidly and took on the characteristics of the extra-tropical counter-current LOW.

The continental low-pressure areas were generally unimportant and normal both in number and type.

The number of high-pressure areas showed an increase over the preceding month, but HIGHS No. VII and VIII were the only ones to cause any marked depressions in temperature.

FREE-AIR SUMMARY.

By L. T. SAMUELS, Meteorologist.

Free-air temperatures at all levels reached by the kites averaged close to the normals for September. It will be noted, however, in Table 1 that fairly large negative departures were found at Due West and Royal Center. These, it is believed, can be accounted for to a large extent by the fact that at these stations prevailingly light winds prevented kite flights on a large number of days. At Due West none was possible for 11 consecutive days, viz, from the 3d to 13th, inclusive, with successful flights on only 11 days during the month, while at Royal Center but 15 days occurred when flights were possible.

Relative humidity departures were of usual magnitude with the exception of Due West. The large positive departures found at this station evidently resulted from the fact that on most of the days on which kite flights were possible the pressure distribution was such as to cause easterly and, consequently, moisture-bearing winds. The vapor pressure averages departed in general from their normals directly as the temperatures. Exception to this is apparent at Due West where, despite the large negative temperature departures, vapor pressures averaged above normal up to 1,500 m. The large positive humidity departures at this station, previously mentioned, however, evidently largely account for this.

It will be observed that in Table 2 that the resultant winds for the month did not vary much from their normals, although a somewhat greater southerly component was found at Ellendale and Royal Center. As a result of this the former station showed a general excess of temperature, although the temperature at Royal Center was below the normal. The comparatively small number of days making kite flights possible at this station undoubtedly had an influence in this respect as the resultant winds found from pilot-balloon observations showed no such preponderant southerly component, but instead a definite westerly one. Pilot-balloon observations from stations north of Groesbeck, i. e., latitude 32°, and eastward from the Rocky Mountains showed the resultant wind above 2,000 m. elevation to be approximately WNW. 8 m. p. s. At Groesbeck, however, the general resultant winds above this height were approximately 2 m. p. s. from the WSW. At Key West, latitude 25° N. for these levels they were found to be slightly north of east, with a force averaging 3 m. p. s.

The large number of extremely high observations obtained at San Juan, latitude 18° N. is especially interesting in that it provides data for finding the resultant wind as high as 10,000 m. for the month with a considerable degree of accuracy. The average height reached at this station based on an observation made every day during the month was 9,000 m. The 10,000 m. level was reached on 13 days, 14,000 m. on 8 days, 21,000 m. on 2 days, and the highest during the month was 24,000 m. on the 27th. From these observations it was found that the direction and velocity were remarkably constant from day to day up to at least 6,000 m. From this height to 15,000 m. and possibly even higher the month showed winds of exceedingly variable direction and only light velocity. It is at least interesting, if not significant, that an easterly component with moderately high velocity was found on the 15th from 17,000 m. to 21,000 m. and on the 27th from 18,000 m. to 24,000 m., the only two observations reaching those heights.

An exceedingly high single-theodolite pilot-balloon observation, reaching an assumed altitude of 33,750 m., was made at Drexel on the morning of the 4th. This showed light winds averaging less than 10 m. p. s. from the ground to 30,000 m. From this altitude to the highest the indicated velocity increased to nearly 40 m. p. s., but there is considerable doubt as to the accuracy of this portion of the observation. The direction was southerly at the surface, but steadily veered in the first 4 kilometers to somewhat north of east, where it remained to the highest level reached.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during September, 1923.*

TEMPERATURE (°C.).

Altitude. m. s. l. (m.)	Broken Arrow, Okla. (233 m.) Mean.	Departure from 6-yr. mean.	Drexel, Nebr. (396 m.) Mean.	Departure from 8-yr. mean.	Due West, S. C. (217 m.) Mean.	Departure from 3-yr. mean.	Ellendale, N. Dak. (444 m.) Mean.	Departure from 6-yr. mean.	Groesbeck, Tex. (141 m.) Mean.	Departure from 5-yr. mean.	Royal Center, Ind. (225 m.) Mean.	Departure from 6-yr. mean.
Surface	22.1	−1.5	18.6	−0.2	22.1	−2.0	16.0	+1.0	25.0	+0.2	19.3	−2.6
250	22.0	−1.4	......	......	21.7	−2.0	......	......	24.5	+0.4	19.2	−2.5
500	20.9	−0.9	18.3	−0.1	19.1	−2.1	16.1	+1.1	23.0	+0.5	17.2	−2.2
750	20.2	−0.3	17.3	−0.1	17.2	−2.2	15.4	+0.9	21.5	+0.5	15.5	−2.2
1,000	19.1	−0.1	16.4	0.0	15.8	−2.3	14.5	+0.9	20.1	+0.3	13.8	−2.4
1,250	17.9	+0.1	15.2	−0.1	14.5	−2.3	13.6	+1.0	18.7	+0.2	12.2	−2.5
1,500	16.6	+0.2	14.0	−0.1	13.0	−2.4	12.5	+1.0	17.4	+0.1	10.9	−2.3
2,000	13.8	+0.1	11.2	−0.1	10.7	−2.1	9.9	+0.9	14.7	−0.1	8.3	−2.2
2,500	11.1	+0.3	8.0	−0.1	7.8	−2.0	6.9	+0.9	12.1	−0.1	5.6	−2.3
3,000	8.2	+0.4	4.8	−0.1	5.4	−1.5	3.7	+0.7	9.7	+0.1	2.9	−2.5
3,500	5.3	+0.7	2.0	+0.1	2.8	−1.3	0.7	+0.4	7.2	+0.2	0.5	−2.3
4,000	2.5	+0.9	−0.5	+0.4	−0.6	−1.5	−2.1	+0.2	4.5	+0.3	−1.0	−1.4
4,500	0.2	+1.3	−2.9	+1.0	......	......	−5.4	−0.5	1.9	+0.3	......	......
5,000	......	......	−5.1	+1.3	......	......	......	......	......	......	......	......

RELATIVE HUMIDITY (%).

Surface	73	+5	72	+7	72	+8	69	+3	74	−2	71	+7
250	73	+5	......	......	73	+9	......	......	74	−2	71	+7
500	68	+2	70	+7	80	+11	68	+3	73	−3	71	+7
750	64	0	67	+7	84	+13	65	+3	73	−3	71	+7
1,000	63	0	64	+6	85	+15	62	+2	71	−2	70	+7
1,250	60	−2	64	+7	82	+15	59	+2	70	−1	67	+5
1,500	58	−2	63	+8	81	+16	57	+3	68	0	65	+4
2,000	52	−4	65	+11	72	+13	50	0	67	+5	63	+5
2,500	47	−4	68	+13	69	+12	47	−3	56	0	51	−3
3,000	52	+3	65	+10	61	+9	52	+1	46	−6	43	−7
3,500	58	+6	61	+8	59	+11	51	+1	47	−2	25	−22
4,000	52	+3	56	+4	79	+21	44	−3	47	+1	20	−28
4,500	44	−4	51	−2	......	......	44	−1	47	+1	......	......
5,000	......	......	44	−7	......	......	......	......	......	......	......	......

VAPOR PRESSURE (mb.).

Surface	19.34	−0.41	15.61	+1.31	19.21	+0.03	12.49	+1.27	23.27	−0.50	16.11	−0.64
250	19.19	−0.43	......	......	19.05	+0.08	......	......	22.56	−0.42	15.90	−0.65
500	16.96	−0.59	14.93	+1.25	17.69	+0.18	12.29	+1.25	21.03	+0.01	14.04	−0.72
750	15.25	−0.51	13.30	+1.04	16.50	+0.29	11.20	+1.09	19.24	+0.16	12.61	−0.75
1,000	14.06	−0.30	12.00	+0.90	15.32	+0.53	10.17	+1.01	17.28	+0.33	11.33	−0.80
1,250	12.72	−0.24	11.05	+0.97	13.40	+0.25	8.98	+0.83	15.66	+0.38	9.72	−1.15
1,500	11.09	−0.33	9.98	+0.95	12.01	+0.22	8.08	+0.76	14.11	+0.50	8.56	−1.12
2,000	8.24	−0.47	8.58	+1.22	9.07	−0.30	6.11	+0.25	11.66	+1.02	7.09	−0.61
2,500	6.41	+0.07	7.25	+1.14	6.97	−0.69	4.89	−0.03	8.40	+0.25	4.88	−0.85
3,000	6.09	+1.28	5.54	+0.51	5.15	−1.12	4.41	+0.16	5.86	−0.62	2.59	−1.62
3,500	5.68	+1.63	4.54	+0.48	4.27	−1.05	3.59	−0.01	5.28	+0.03	1.21	−1.93
4,000	4.41	+1.48	3.68	+0.30	4.19	−0.84	2.75	−0.23	4.61	+0.43	0.66	−1.95
4,500	3.61	+1.35	3.04	+0.17	......	......	2.24	−0.37	4.41	+0.77	......	......
5,000	......	......	2.64	+0.22	......	......	......	......	......	......	......	......

Table 2.—*Free-air resultant winds (m. p. s.) during September, 1923.*

Altitude. m. s. l. (m.)	Broken Arrow, Okla. (233 meters).				Drexel, Nebr. (396 meters).				Due West, S. C. (217 meters).				Ellendale, N. Dak. (444 meters).				Groesbeck, Tex. (141 meters).				Royal Center, Ind. (225 meters).			
	Mean.		6-year mean.		Mean.		8-year mean.		Mean.		3-year mean.		Mean.		6-year mean.		Mean.		5-year mean.		Mean.		6-year mean.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 5° W.	3.6	S. 2° W.	3.6	S. 20° E.	1.1	S. 12° W.	1.8	N. 63° E.	3.0	N. 69° E.	2.4	S. 8° E.	0.1	N. 81° W.	0.8	S. 22° E.	3.0	S. 23° E.	2.0	S. 28° W.	1.6	S. 53° W.	1.5
250	S. 4° W.	3.7	S. 2° W.	3.7	...	...	...	...	N. 58° E.	3.1	N. 65° E.	2.1	...	...	...	...	S. 23° E.	3.9	S. 21° E.	2.8	S. 28° W.	1.9	S. 53° W.	1.8
500	S. 10° W.	4.9	S. 10° W.	5.1	S. 9° E.	2.3	S. 12° W.	2.6	N. 62° E.	3.5	N. 63° E.	2.5	S. 12° W.	0.6	S. 84° W.	1.0	S. 18° E.	4.8	S. 14° E.	4.1	S. 30° W.	3.6	S. 50° W.	3.3
750	S. 25° W.	5.4	S. 17° W.	5.8	S. 8° W.	3.0	S. 25° W.	3.6	N. 67° E.	3.9	N. 56° E.	2.4	S. 40° W.	2.2	S. 68° W.	1.7	S. 11° E.	4.8	S. 8° E.	4.6	S. 37° W.	3.9	S. 58° W.	4.1
1,000	S. 36° W.	5.2	S. 25° W.	5.5	S. 21° W.	3.2	S. 35° W.	4.0	N. 69° E.	3.6	N. 49° E.	2.4	S. 46° W.	2.5	S. 69° W.	2.5	S. 7° E.	4.5	S. 7° E.	4.7	S. 44° W.	5.3	S. 66° W.	4.9
1,250	S. 44° W.	5.0	S. 29° W.	5.3	S. 34° W.	3.0	S. 50° W.	4.2	N. 61° E.	3.2	N. 37° E.	2.5	S. 57° W.	2.9	S. 72° W.	3.0	S. 6° E.	4.6	S. 7° E.	4.8	S. 53° W.	6.0	S. 70° W.	5.9
1,500	S. 55° W.	5.1	S. 38° W.	5.3	S. 54° W.	3.2	S. 60° W.	4.9	N. 61° E.	2.7	N. 31° E.	2.7	S. 65° W.	3.6	S. 79° W.	3.9	S. 7° W.	4.5	S. 7° E.	4.6	S. 53° W.	6.5	S. 73° W.	6.6
2,000	S. 62° W.	5.0	S. 44° W.	6.0	S. 64° W.	4.1	S. 69° W.	5.8	N. 58° E.	1.1	N. 16° E.	2.1	S. 73° W.	4.4	S. 80° W.	5.3	S. 14° W.	3.7	S. 5° E.	4.2	S. 58° W.	9.1	S. 74° W.	8.7
2,500	S. 72° W.	5.8	S. 49° W.	5.4	S. 62° W.	7.4	S. 76° W.	7.5	N. 42° E.	0.1	N. 19° E.	1.9	N. 88° W.	7.2	S. 85° W.	7.3	S. 11° W.	3.5	S. 9° E.	4.2	S. 63° W.	10.5	S. 76° W.	10.3
3,000	S. 77° W.	7.1	S. 44° W.	6.1	S. 85° W.	8.6	S. 83° W.	9.3	S. 11° E.	1.4	N. 55° E.	2.0	N. 77° W.	8.9	S. 89° W.	9.3	S. 9° W.	3.6	S. 8° E.	4.2	S. 55° W.	13.7	S. 74° W.	12.7
3,500	S. 73° W.	5.3	S. 49° W.	5.3	N. 86° W.	11.0	N. 89° W.	10.5	S. 24° E.	2.3	N. 60° E.	3.5	N. 82° W.	10.1	S. 87° W.	10.7	S. 19° W.	3.0	S. 2° E.	3.8	S. 57° W.	12.6	S. 83° W.	12.5
4,000	S. 84° W.	7.6	S. 71° W.	6.9	N. 81° W.	9.5	N. 76° W.	12.1	N. 80° E.	0.9	N. 57° E.	4.0	N. 62° W.	13.0	N. 79° W.	12.5	S. 33° W.	5.0	S. 2° E.	4.4	S. 22° W.	13.3	N. 86° W.	10.0
4,500	N. 88° W.	11.1	S. 88° W.	8.8	N. 73° W.	10.4	N. 68° W.	13.8	...	...	...	...	N. 67° W.	10.3	N. 69° W.	13.6	S. 47° W.	6.7	S.	6.9	...	...	...	...
5,000	S. 68° W.	12.5	N. 86° W.	13.8	N. 22° W.	13.6	N. 64° W.	15.7	...	...	...	...	N. 60° W.	15.0	N. 80° W.	13.7	N. 67° W.	3.6	S. 27° E.	5.5	...	...	...	...

THE WEATHER ELEMENTS.

By P. C. Day, Meteorologist, in Charge of Division.

PRESSURE AND WINDS.

The distribution of the atmospheric pressure during September, 1923, varied in some respects from that usually expected, the most important being the persistence of high pressure over the Northeastern States and the Canadian Maritime Provinces, where the change from the preceding month was nearly twice as great as normal. In other localities the changes from normal were comparatively small, though the averages for the different sections were above normal save for small areas in the Southeastern States, in the near Northwest, and along the California coast, where they were somewhat less than normal.

The cyclones were mainly unimportant, though there was rather persistent low pressure and cyclonic activity in the middle and southern Great Plains, where rainfall was frequent and heavy, particularly at the first of the month and again from about the 13th to 20th. Important cyclonic disturbances, at least from the precipitation standpoint, although there was no great depression of the barometer, occurred from the 16th to 18th, when moderately low pressure moved from the central Rocky Mountain region to the northward of Lake Superior. Precipitation from this cyclonic area covered wide areas in the Great Plains and adjacent region, and was particularly heavy in Oklahoma, eastern New Mexico, and portions of adjacent States. This was quickly followed by a second slight depression of the barometer that appeared on the morning of the 19th over Oklahoma and southern Kansas, and by the following morning had developed into a cyclonic storm of considerable proportions, central in Iowa, attended by precipitation over wide areas in the Great Plains, Mississippi Valley, and adjacent areas. This storm quickly diminished in force and during the following day or two lost its identity over the Northeastern States, although the accompanying precipitation was unusually widespread and frequently heavy over much of the country from the Mississippi River eastward, except in portions of the Gulf States.

The last decade of the month was mainly free from cyclonic storms of importance, save that from the 24th to 26th a small low area, but with a considerable depression of the barometer, moved from the vicinity of eastern Wyoming northward over the Dakotas and eastern Montana into the adjacent Canadian Provinces, attended by a considerable rain area, with some local heavy falls for that region. A slight barometric depression over the eastern slope of the Rocky Mountains during the 27th to 29th gave some unusually heavy rains for the season of the year over that region and the adjacent Great Plains. At points in Wyoming, South Dakota, and Nebraska the total fall during this period ranged from 2 to 7 inches or more.

The most important anticyclone of the month moved into the upper Missouri Valley on the morning of the 10th, remaining nearly stationary, but increasing in magnitude for nearly 48 hours, when it gradually moved to the eastward, accompanied by clear and cool weather successively over northern and central districts from the Rocky Mountains to the Atlantic seaboard until the end of the second decade. During the last decade moderate anticyclonic conditions prevailed very generally over the northern and central districts from the Great Lakes eastward, attended mainly by fair weather and moderate temperature.

In the absence of important cyclones or anticyclones the air circulation was moderate and high winds or severe storms of any character were infrequent. A list of the most important storms of the month is given at the end of this section.

The average pressure for the month exhibited no strong barometric gradients and the prevailing wind directions were mainly variable, though usually from southerly points in the Great Plains, Mississippi Valley, and from the Lake region to New England, from northerly points over the Southeastern States, and variable in the far West.

TEMPERATURE.

September, 1923, was markedly free from sudden important temperature changes; in only a few instances were the 24-hour changes equal to or in excess of 20°, and these were confined to the more northern stations or to the western mountain districts, where day-to-day temperature changes are liable to be large occasionally at this period of the year.

The first few days of the month had seasonable temperatures in practically all parts of the country, save that on the 3d and 4th the warmest weather of the year was reported from points in the Dakotas and Montana.

The week ending September 11 was moderately cool at the beginning over the western mountains, and again near the end in nearly the same districts, both cool areas extending slowly eastward, but largely losing their

identity as they approached the Atlantic seaboard. In the far West this period was distinctly warm, the averages for the week ranging up to 12° above normal in the interior of California, the 7th and 8th being particularly warm, with the highest temperatures ever observed in September at a number of points in California, Oregon, and Nevada. In the central and eastern districts the temperatures for this week were mainly near the normal.

The week ending the 18th, being mainly under the influence of high barometric pressure over the northern and central districts from the Rocky Mountains eastward, was cool throughout this region, the weekly averages ranging from 3° to 9° below normal. About the 13th to 15th the coldest weather of the month was experienced over a large area from the Dakotas and Nebraska eastward to the Great Lakes, and during the 16th to 18th this cold area extended to the Middle and North Atlantic States. At a few points in the upper Mississippi Valley the minimum temperatures recorded during this period were the lowest ever observed in September. Along the Gulf coast, and westward to southern California, and generally over the Pacific Coast States this week was moderately warm. In California hot, drying winds on the 16th and 17th favored the spread of numerous forest and other fires, one of which, becoming beyond control, caused damage estimated at $10,000,000 in the city of Berkeley.

A sharp return to more seasonable temperatures, following the cool week ending the 18th, occurred during that ending the 25th over the central and eastern districts, and moderately warm weather was the rule, although the first few days continued cool over the Northeastern States. In the far West the week was mainly cooler than normal, with a sharp drop near the end over the southern Plateau region. The last 5 days of the month continued warm over the districts east of the Rocky Mountains, while to the westward temperatures lower than normal were the rule.

The average temperature for the month was generally above normal throughout both the United States and Canada, save over extreme eastern Canada and the adjoining portions of Maine, over a narrow area from Louisiana northeastward to Lake Michigan, and over portions of the far Southwest, as indicated on Chart III. The departures both above and below normal were mainly small.

The warmest periods of the month for the different sections were confined mainly to the first decade, although in portions of the Ohio Valley and Tennessee the warmest period was about the 25th to 27th.

Maximum temperature of 100° or above were reported from nearly all the States from the Great Plains westward; the highest observed, 120°, occurred in southern California.

The coldest weather of the month in the districts east of the Rocky Mountains was confined largely to the period from the 13th to 18th, during which unusually high atmospheric pressure dominated the northern and central districts and severe frosts occurred during this period in portions of the principal corn-growing regions, considerable damage resulting to that crop in Iowa and in other States to the eastward where that crop as well as others had not fully matured.

PRECIPITATION.

Considering the country as a whole, the precipitation was above normal over the greater part, although there were marked deficiencies in Tennessee and the Gulf States east of the Mississippi River, and moderate deficiencies in portions of the Northeastern States, the upper Lake region, and the far Northwest.

The precipitation was greatly in excess of the normal over most of the Great Plains States, the lower Missouri and middle Mississippi Valleys, and locally in Michigan, along the Texas coast, and at points in Arizona and California. In Oklahoma the severe drought of July and August was broken by the rains of the 1st and 2d, and the month, as a whole, was the wettest September of record; also in Kansas the month was close to the wettest of record, while in central and eastern Wyoming and the adjacent portions of Montana and South Dakota the excesses were locally large, due to heavy rains near the end of the month, causing much damage to transportation systems by washouts, and to agricultural interests by flooding of crops, injury to hay, etc. Heavy rains from the 16th to 18th in northeastern Arizona caused many washouts on highways and railroads of that locality and much other property damage. In California showers during the last decade broke the long dry spell in that State.

Over the Atlantic coast districts, where more or less severe drought had existed during several preceding months, good rains were the rule and the monthly amounts were usually in excess of the normal, but on account of the previous deficiency the water supply continued short, although the surface supply was sufficient for agricultural needs.

In the East Gulf and the South Atlantic States there was a marked deficiency in precipitation as compared with the normal, and late crops and truck were suffering for rain, and the water supply for power purposes was reported in many instances as being insufficient. At some points in these districts the total fall for the month was the least of record for September, notably at Montgomery, Ala., where only 0.12 inch occurred during the entire month, the least in more than a half century of record.

SNOWFALL.

Only light snow occurred at any of the lower elevations. At points in the upper Lake region the light snows about the 12th were the earliest of record for that section and the first snow of the season was reported at a few points in New York.

In the mountains of California the first snow of the season occurred during the last decade, when amounts from 14 to 20 inches fell above the 5,000-foot level, but this soon melted except at the higher elevations. At Modena, Utah, the snow of the 27th, 0.7 inch, was the heaviest ever observed at that place so early in the season. Considerable snow fell in some of the high mountains of Nevada, Utah, and Wyoming and other parts of the Rocky Mountains.

RELATIVE HUMIDITY.

Like precipitation, the relative humidity was above the normal over the greater part of the country, the excess over the middle and southern Great Plains and adjacent regions ranging from 5 to 10 per cent. In the dry region of the East Gulf and South Atlantic States there was a moderate deficiency and like conditions occurred over the northern border States from Minnesota to Washington, and locally in Oregon and California.

SEVERE LOCAL STORMS, SEPTEMBER, 1923.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Cairo, Ill	3	3:00-3:17 p. m.				Tornado	No damage reported	Official, U. S. Weather Bureau.
Atlantic City, N. J	4	4:40-7:00 a. m.				Thunderstorm	One house struck by lightning. No other damage reported.	Do.
Marinette, Ariz	12					Rain and wind	Cotton damaged and tents blown away	Do.
Miami, Fla	13	10:36 a. m.-12:33 p. m.				Thunderstorm	Streets flooded and some damage caused by lightning.	Do.
Berkeley, Calif., and vicinity	16-17				$10,000,000	High winds	Grass and forest fires becoming beyond control entered into the city of Berkeley, causing great damage.	Do.
Oklahoma City, Okla	18	6:02-6:40 p. m.			1,000,000	Hail, rain, and wind.	Heavy property damage; many persons injured by hail.	Do.
Harvey and Sedgwick Counties, Kans.	26	6:00 p. m.-12:00 midnight.			210,000	Tornado and rain	Heavy property damage by wind and floods. Two persons injured.	Do.
Pine Bluff, Wyo. (near)	27	p. m.				High winds	41 empty freight cars blown from track	Do.
Cheyenne, Wyo. (10 miles southeast of).	27				8,000	Wind and rain	Buildings and fences blown down and much farm machinery damaged.	Do.
Albany, N. Y., and vicinity	28			1		Electrical	Some livestock killed	Do.
Council Bluffs, Iowa (southeast part of).	28	7:50 p. m.		5	15,000	Tornado	Path several hundred feet wide, not exceeding 3 miles in length: 1 house demolished and a number damaged to varying extent: trees uprooted. Extensive damage in city by floods.	Do.

STORMS AND WEATHER WARNINGS.

WASHINGTON FORECAST DISTRICT.

By EDWARD H. BOWIE, Supervising Forecaster.

At the beginning of the month the storm reported during the closing days of August as having formed to the eastward of the island of St. Martin, West Indies, was moving northwestward and on the 2d and 3d it produced strong winds and considerable rainfall in the vicinity of Bermuda. Its center apparently passed northward immediately west of Bermuda and thence its course was to the northeast, but being unable to continue to move northeast against the current flowing from an area of high barometric pressure to the northward it changed its course to the westward and finally again to the northward, so that on the 9th the center of the disturbance was south of Sable Island, from which position it moved northward to Newfoundland. Shipping was kept advised by means of radio as to the presence and movement of the disturbance.

During the 14th another disturbance but of extratropical origin formed off the coast between Cape Hatteras and Bermuda and moving northeastward increased greatly in intensity, passing beyond Newfoundland on the 19th. As in the former instance shipping was well advised by radio concerning the movement and intensity of this disturbance.

Following this disturbance the weather off our eastern and southern coasts remained relatively tranquil until the 25th, when reports by cable from the West Indies and radio reports from vessels at sea gave unmistakable indications of the forming of a disturbance northwest of Haiti. Based on the observations received at 8 p. m. of the 25th, the following advice was issued to ports and for broadcast by radio:

Disturbance apparently over Old Bahama Channel will move west-northwest and increase in intensity. Vessels in Bahaman waters and Florida Straits should exercise every precaution.

As forecast, this disturbance advanced west-northwestward and the morning of the 26th its center was near and southeast of Nassau, Bahamas, where the pressure was 29.54 inches, the wind northwest 40 miles, and the weather raining. Continuing to advance slowly, this disturbance moved northwestward during the next 24 hours and then its course changed to north and northeastward and by 8 a. m. of the 28th its center was in approximately lat. 32° N. and long. 75° W. and moving northeast. During the following 24 hours this disturbance moved eastward and during the night of the 29th its course changed to northeast and on the morning of the 30th its center was near lat. 33° N. and long. 69° W. From this position its course was north-northeastward, and on October 2 its center passed over Newfoundland.

This disturbance was one of great intensity and very low level of the barometer. The lowest pressure reported was approximately 28.50 inches, while several vessels reported winds of hurricane force. Because of its having been detected in the process of formation and its path and intensity having been accurately described in special advices by radio to vessels at sea, minimum amount of damage was done to shipping. Moreover, since the center of the disturbance did not reach the coastal line, no extraordinary wind and weather conditions were recorded at land stations. Nevertheless, and to guard against vessels in port putting out to sea, storm warnings were displayed on the Atlantic coast in connection with this storm at all points at and south of the Virginia Capes, and on the afternoon of the 26th when the disturbance was moving northwestward and its center near Nassau, hurricane warnings were displayed along the coast at and between Savannah, Ga. and Jupiter Inlet, Fla.; but the following morning when observations showed that the disturbance would move northward, these hurricane warnings were lowered and northeast storm warnings substituted.

That the advices issued were greatly appreciated and of direct benefit to shipping off the Atlantic coast, the following extracts from letters received will attest. These letters were addressed to the New York office of the Weather Bureau. They follow.

From the general manager, marine department of the United Fruit Co. (dated October 9, 1923):

I wish to thank you, on behalf of the United Fruit Co., for the service which you rendered us during the recent hurricane. Your various reports and the information submitted by you were greatly appreciated by all concerned. (Signed) Asa F. Davison.

From the manager of the marine department, Standard Oil Co. of New Jersey (dated September 26, 1923):

I wish to thank you for your telephone advice of this noon that a hurricane is central this morning near Nassau, moving northwest, across

the track of ships to and from Gulf ports, which timely information is very much appreciated. (Signed) Robert L. Hague.

From the port captain (New York) of the Pan-American & Transport Co. (dated October 1, 1923):

I always feel when valuable service is rendered gratuitously that it is the least reward one can do is to show his appreciation. We certainly appreciate prompt reports from you giving us details of last week's hurricane; having ships in its track we were naturally anxious. We have since heard from them that by receiving weather reports enabled them to steer clear of the hurricane track. Thanking you for past performances and trusting for future assistance, etc. (Signed) H. A. Henshaw.

From the manager, Southern Pacific Co. (dated October 1, 1923):

While I have never had the pleasure of personally meeting you, I recall having received many communications from you with reference to weather conditions on the coast, which have been invaluable to our outgoing ships, as well as ships that were at sea and could be reached by wireless, in advising them of weather conditions they might expect to encounter. I consider the Weather Bureau and the service which it renders of inestimable value to shipping and want to thank you for keeping us informed of storm conditions on the coast, and hope you will continue to do so in the interest of coastwise shipping. (Signed) C. W. Jungen.

From the captain of the *Southern Cross*, a press report dated October 7, 1923, en route from Buenos Aires to New York:

"That we came through it [the hurricane] without serious trouble," the skipper said, "I attribute to the radio warnings sent from New York (?) by the Weather Bureau. The bureau let us know what to expect, and acting upon this advice, we skirted the rim of the biggest blow I have seen in all my experience. (St. Louis Post Dispatch.)

The track of this hurricane and reports from vessels encountering it will be found elsewhere in this number of the REVIEW.

On several days during the month frost warnings were required for the northern part of the Washington forecast district, and these were issued as occasion demanded.

CHICAGO FORECAST DISTRICT.

The principal features of the weather conditions in the Chicago forecast distr ct during the month of September were the cool period during the second and a portion of the third week, a warm period the closing week of the month, and the exceptional storm in the West which caused torrential rains in some of the Plains States and on the eastern Rocky Mountain slope.

A cool high area appeared in British Columbia on the 9th and gradually moved southeastward, bringing with it temperatures below normal and finally frosts over the Northwestern States, as far east as the Upper Lake Region on the 13th, and by the 14th southward almost to the Ohio Valley. The southwestern portion of the district escaped, there being no frosts reported in Missouri or Kansas. Frost warnings were issued to nearly all points threatened in advance.

Special frost warnings were also sent to the Wisconsin cranberry marshes and the tobacco fields, and low temperatures were reported in both these areas on the mornings of the 12th and 13th.

The warnings to the cranberry marshes were discontinued at the end of September, and some of the growers expressed much appreciation of the value of the service during the season.

Mr. Charles L. Lewis, Beaver Brook, Wis., writes as follows:

The freeze of September 12 and 13, or rather 13 and 14, caused very little damage in this county, as we all had plenty of water and used it. We had ample warning of the frost and were able to protect with very little loss. I understand, however, that they had considerable damage in Wood County and near Mather, where their water supplies are limited.

Thanking you very much for the very splendid services that you have rendered to us during the season just closed.

Mr. Ermon C. Bennett, of Wisconsin Rapids, Wis., in his letter of September 27, expresses appreciation as follows:

I wish to thank you on behalf of the cranberry growers of this vicinity for your interest in sending frost warnings. The warnings have been a great help and the marsh people depend on them more each year.

It is understood that considerable damage was done to the tobacco crop where advantage was not taken of the warnings issued.

No general windstorms occurred on the Great Lakes during the month, and the only storm warning was that issued to Lake Michigan ports on the 20th. The winds, however, did not reach gale force, and as the storm seemed to diminish in energy the warnings were lowered after a short display.

Special forecasts were made for some State fairs with apparent success.

The special forecast that was sent to Sturgeon Bay, Wis., for the orchardists in Door County in connection with spraying, was discontinued on the 11th. Mr. Leon K. Jones, plant pathologist, in charge of this special work, states under date of September 9:

The weather predictions that you have sent this season have proved of great benefit to myself and many of the fruit growers of the district. The service may, however, be discontinued at this time.

H. J. Cox.

NEW ORLEANS FORECAST DISTRICT.

Moderate weather conditions prevailed generally during the month of September. No storm warnings were issued and no storm winds of sufficient duration to constitute a storm occurred. Small-craft warnings were displayed on the 16th in the Corpus Christi section, ordered by the official in charge at Corpus Christi. No fire-weather warnings were necessary and none was issued.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

Unusually cool weather prevailed in the Denver forecast district in September. Frost warnings were issued on a number of dates for the various parts of the district. They were grouped in the following periods, 10–13, 17–20, 24–26, and 27–29. For the most part they were justified by the weather conditions that followed.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

During September the weather in this district began to show the transition from summer to autumn. Storms from the North Pacific moved inland at somewhat lower latitudes and influenced the weather over the Pacific coast.

A period of very warm weather prevailed during the first decade and records of high temperatures in September were broken at Sacramento, Reno, and Portland on the 7th, and at Winnemucca on the 8th.

Southwest storm warnings were ordered at Washington stations on the 23d, and were verified.

Fire-weather warnings were issued on the 6th, in Washington, Oregon, Idaho, and northern California, and on the 16th, over the entire district. The warnings were timely and verified.

Rain warnings were issued in northern California on the 13th, 21st, and 22d, and in southern California on the 22d. These were generally verified.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

The only floods east of the Mississippi River were very moderate ones in the Roanoke River of North Carolina and the Saluda and Santee Rivers of South Carolina. The Santee flood was simply the end of the August flood, while the Saluda flood was a one-day flood on the first day of the month, for which warnings had been issued on August 29. The flood was caused by heavy rains in the Piedmont section. The Roanoke flood was very local in character and no warnings were issued.

General rains fell over the State of Oklahoma from September 14 to 19, inclusive, with heavy rains on September 18 and 19. As a result high water was experienced in all streams of the State, although there were no flood stages except in the North Canadian River, where the flood stages were quite generally, although but slightly, exceeded on September 20 and 21, and again on September 25 at Oklahoma City on account of additional heavy rains above. Low bottom lands along the North Fork, and a small section of Oklahoma City were flooded, but the damage was slight. Warnings were issued on September 19 and again on September 22, for the lower river flood.

On the evening of September 26, a tornadic storm, mentioned elsewhere in this REVIEW, occurred in the vicinity of Halstead, Sedgwick, Newton and Hesston, Kans. The storm lasted only about six hours, but the rainfall measured from 4.52 to 9 inches. Naturally, all streams in the territory covered rose rapidly and decidedly to above the flood stages, especially the Little Arkansas River. At Sedgwick on this river the crest stage of 24.8 feet on the afternoon of September 27 was 6.8 feet above the flood stage, and at Wichita, Kans., on the Big Arkansas River, the crest stage of 10.5 feet on the morning of September 29, was 1.5 feet above flood stage. At the Shrine Clubhouse on the Little Arkansas River at Wichita, the crest stage was materially lowered to 1.5 feet above the flood stage of 12 feet by diverting some of the flood waters through the canal into Chisholm Creek.

About one-quarter square mile of territory within the city of Wichita was flooded by overflow waters from Chisholm Creek, and about one-half square mile of residence section along the Little Arkansas River. Along the Big Arkansas River the damage was slight.

Warnings were issued promptly on the morning of September 27, and distributed as widely as possible.

Losses as reported totaled $43,000, of which $18,000 was to bridges and highways and $14,000 to crops. Crop losses were small as most crops had been harvested.

Precipitation was general over Wyoming from September 27 to 30, inclusive, and heavy on September 27 and 28 over the drainage area of the North Platte River, the rainfall ranging from 1 to nearly 3½ inches. As a result the North Platte River and its tributaries rose rapidly, At Coal Creek, Wyo., about 14 miles east of Casper, a washout during the night of September 28 caused a disastrous railroad wreck, a locomotive and a number of cars dropping into the streams, causing the loss of at least 17 lives, and very probably more. Coal Creek empties into the North Platte River within a few yards of the scene of the accident.

From the Wyoming-Nebraska line to North Platte, Nebr., the North Platte River rose rather more than 2 feet on an average, and at North Platte the crest stage was 6.0 feet, or 1 foot above the flood stage. East of North Platte the crest flattened out considerably. The excessive rainfall of September 28 also caused severe local floods in the vicinity of Omaha, Nebr., and Council Bluffs, Iowa, entirely through overflows of small tributaries. At Louisville, Nebr., about 20 miles southwest of Omaha, the flood waters from Mill Creek drowned 12 persons in one house as it was swept downstream. Several bridges were washed away and a large number of houses wrecked. Across the Missouri River in Council Bluffs, Iowa, conditions were much the same and six lives were lost in the city.

It is impossible, of course, to issue warnings for the floods in small streams that are caused by torrential rains of short duration, but for the North Platte River in Nebraska, advisory warnings were issued in ample time. The damage reported amounted to about $760,000, although there is reason to believe it was much more. Of this amount about $500,000 fell to the State of Wyoming. No estimate of the losses on the Iowa side of the Missouri River has been received.

Almost similar conditions prevailed on September 30, in the Powder River Valley of southeastern Montana and northeastern Wyoming, and overflow waters from Goose Creek inundated the northern and eastern sections of the city of Sheridan, Wyo. No estimate of the damage caused by this flood has been received, but it must have been great, as in the vicinity of Broadus, Mont., the Powder River overflow water was reported to have covered the landscape for miles and miles. Fortunately no lives were lost.

During the early part of the month heavy rains in eastern Mexico and southern Texas caused severe floods in the lower Rio Grande, and before the flood waters had receded to any extent, additional heavy rains caused a second flood of almost similar proportions. At Rio Grande City, Tex., the crest of the first flood was 23.3 feet on September 11, and of the second, 21.5 feet on September 22. Flood stage is at 15 feet. Below Rio Grande City the first flood overtook the second one and flood stages continued at the close of the month.

While the flood stage was not reached at Eagle Pass, Tex., the low bridge at that place was carried away on September 17. Levees gave way near Mercedes, Tex., and a portion of the country for 20 miles to the northward was flooded. The floods caused damage amounting to $80,000, of which $40,000 was to highways, levees and bridges, and $40,000 to crops and business interests.

Warnings for these floods were first issued on September 8, and continued daily thereafter.

There was a flood in the Colorado River of Arizona from the Utah line to Topock. At the time a survey party of the United States Geological Survey was working in the Grand Canyon of the Colorado, and it was supplied with a radio outfit for communication with the Los Angeles, Calif., Times. Warnings were sent to the Times on September 18, and additional warnings of dangerously high stages were sent on the following day when the stage at Grand Canyon, Ariz., was 25.2 feet, rising, with a discharge of 101,400 second-feet. The crest stage at Grand Canyon was 27.5 feet at 6.30 p. m., September 19. Unfortunately the radio apparatus in the canyon failed to function properly, and the warnings were not received. However, the surveying party suffered no casualties.

Warnings were also issued on September 20, for the lower Colorado River, but, as the flood had probably been more or less local in character, the peak of the flood became considerably depressed in its progress along the lower Colorado, and the floods failed to materialize.

Heavy and almost continuous rains fell over northeastern Arizona from September 16 to 18, inclusive, and for several days that portion of the State east of Flagstaff was cut off from the remainder of the State. The main line of the Atchison, Topeka & Santa Fe Railroad was put out of commission by washouts, State highways were rendered impassable, and telegraph and telephone communication suspended. The principal damage occurred at and in the vicinity of the town of Holbrook at the junction of the Rio Puerco and Little Colorado Rivers, where many buildings, including residences, were washed away and one life was lost. Streets were inundated and much property along the river banks carried away by erosion. Trains were rerouted through western New Mexico and southern Arizona, and one such train en route from Phoenix, Ariz., northward, was wrecked near Wickenburg, Ariz., resulting in the death of four persons. The rainfall at Wickenburg during September 17 and 18 amounted to 4.50 inches.

Flood stages during September.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.	*Feet.*			*Feet.*	
Roanoke: Weldon, N. C.	30	25	25	30.0	25
Saluda: Chappels, S. C	14	1	1	14.4	1
Santee:					
Rimini, S. C	12	(1)	4	13.2	2
Ferguson, S. C	12	2	7	12.5	5
MISSISSIPPI DRAINAGE.					
Arkansas: Wichita, Kans	9	28	29	10.5	29
Purgatoire: Higbee, Colo	4	18	18	5.0	18
Little Arkansas:					
Sedgwick, Kans	18	27	28	24.8	27
Hellers Grove, Kans	12	14	15	15.4	14–15
Midian Shrine, Kans. (Wichita, Kans.)	12	28	28	13.5	28
Canadian, North Fork:					
Woodward, Okla	3	18	21	5.3	19
Canton, Okla	4	20	20	4.2	20
Oklahoma City, Okla	12	20	20	12.2	20
Do	12	23	25	13.3	24
WEST GULF DRAINAGE.					
Nueces: Cotulla, Tex	15	7	10	16.0	7
RIO GRANDE DRAINAGE.					
Rio Grande:					
Mission, Tex	24	12	13	24.5	13
Do	24	23	25	25.4	24
Rio Grande City, Tex	15	9	13	23.3	11
Do	15	21	24	21.5	22
San Benito, Tex	21	10	(2)	23.3	22–25
COLORADO DRAINAGE.					
Colorado: Lees Ferry, Ariz	12	20	20	13.5	20

[1] Continued from August.
[2] Continued into October.

MEAN LAKE LEVELS DURING SEPTEMBER, 1923.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., October 3, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during September, 1923:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.10	579.64	571.55	245.03
Above or below—				
Mean stage of August, 1923	+0.04	−0.12	−0.15	−0.38
Mean stage of September, 1922	−0.56	−0.73	−0.77	−1.00
Average stage for September last 10 years	−0.66	−1.09	−0.94	−1.16
Highest recorded September stage	−1.98	−3.79	−2.39	−2.58
Lowest recorded September stage	+0.61	−0.02	+0.27	+1.03
Average relation of the September level to:				
August level		−0.2	−0.3	−0.4
October level		+0.2	+0.3	+0.4

[1] Lake St. Clair's level: In September 574.49 feet.

EFFECT OF THE WEATHER ON CROPS AND FARMING OPERATIONS, SEPTEMBER, 1923.

By J. B. KINCER, Meteorologist.

The weather during September was favorable, in the main, for field work and farming operations made satisfactory advance in most sections of the country. The soil condition was especially favorable for the preparation for wheat seeding in the central valleys and Great Plains States, and there was sufficient rain for improvement in the far Northwest.

Threshing small grains made rapid progress in the more northwestern districts, but in some parts of the upper Mississippi Valley, especially in Iowa, frequent rains were rather unfavorable for threshing oats, though conditions improved after the first few days of the month. Rainfall in the lower Great Plains was particularly timely for the preparation of wheat land in some sections where it had been too dry. At the close of the month the soil had again become too dry in the more northwestern States.

Unseasonably cool weather prevailed in north-central districts about the middle of the month, when freezing temperatures occurred in numerous localities in the northern border States from North Dakota eastward. Heavy to killing frosts occurred in most sections of Minnesota and Wisconsin, with severe damage to some crops, particularly to late truck and gardens. There was also a varying amount of frost damage in Iowa, northern Illinois, central and northern Indiana, Ohio, New York,

and New England. Much late corn was caught in Minnesota and Wisconsin, but in Iowa damage was largely confined to the north-central and northeastern portions, where it was rather heavy in some sections. Potatoes were heavily damaged in some Central-Northern States, while tobacco suffered severely in Wisconsin. Little or no frost injury occurred during the latter part of the month. During this period corn ripened rapidly in the Great Plains States, but maturity was slow in the Ohio and upper Mississippi Valleys, because of persistently damp, cloudy weather.

The drought that had prevailed during August in the western portion of the Cotton Belt was effectively broken, but there was no material improvement in the general condition of cotton in that area, while frequent rains interrupted picking and ginning, particularly in the northwestern portion of the belt. There was little change, likewise, in the condition of cotton in the eastern portion, though seasonable temperatures and generally light rainfall throughout the month were favorable for picking and ginning, which made rapid progress. At the close of the month picking was nearly completed in the southern portions of Mississippi and Alabama, well advanced in Georgia, and about finished in the southern counties of South Carolina.

Pasture lands continued in unusually good condition for the season in nearly all sections east of the Rocky Mountains, except in portions of the east Gulf States, and, during much of the month, in parts of the middle Atlantic coast area where moisture was deficient. Widespread rains in nearly all section of the country from the Great Plains eastward during the week ending September 25 were very beneficial to pastures, especially in New York, New Jersey, and Pennsylvania, while, at the same time, the range in much of the far Southwest was improved by generous showers.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September, 1923.

Section.	Temperature.								Precipitation.					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	76.2	+1.1	2 stations	96	[2] 13	Valley Head	46	25	1.23	−2.17	Eufaula	4.55	2 stations	0.00
Alaska														
Arizona	69.9	−2.8	2 stations	113	[2] 5	Spring Valley R. S.	14	27	1.72	+0.39	Mormon Lake	9.44	Florence	0.00
Arkansas	73.0	−0.9	Booneville	98	11	Dutton	45	[2] 23	5.56	+2.23	Mena	13.91	Warren	1.39
California	69.1	+2.0	Greenland Ranch	120	9	Tamarack	20	26	1.23	+0.68	Helm Creek	6.02	2 stations	0.00
Colorado	55.0	−2.1	Lamar	97	9	Silverton	10	28	1.66	+0.27	Palisade Lake	5.38	Grover	T
Florida	79.7	+0.4	3 stations	98	[2] 4	Quincy	57	29	4.75	−1.89	St. Cloud	9.83	Bluff Springs	1.02
Georgia	76.5	+1.5	Alapaha	100	7	Clayton	41	21	1.97	−1.70	Millen	6.05	Newnan	0.10
Hawaii	75.5	+0.8	2 stations	93	[2] 29	2 stations	52	[2] 3	6.40	−0.13	Pahuamimi	39.60	2 stations	0.00
Idaho	59.9	+2.6	Glenns Ferry	104	2	Stanley	12	6	0.68	−0.33	Lifton	2.28	Spencer	T
Illinois	66.6	−0.4	Carbondale	95	28	Mount Carroll	28	14	3.98	+0.47	Hillsboro	7.32	Mascoutah	1.24
Indiana	67.0	+0.3	Crawfordsville	95	4	Connersville	28	14	3.40	+0.40	South Bend	7.83	Williams	0.93
Iowa	64.2	+0.8	6 stations	92	[2] 3	2 stations	28	14	5.79	+2.43	Washington	12.14	Centerville	1.88
Kansas	69.6	+0.1	2 stations	101	10	St. Francis	31	29	4.21	+1.40	Medicine Lodge	13.36	Bird City	0.48
Kentucky	69.8	−0.2	3 stations	94	[2] 27	Farmers	30	16	2.87	+0.11	Paducah	5.34	Scott	0.60
Louisiana	77.8	+0.1	Dodson	97	27	2 stations	50	[2] 24	5.24	+1.24	Grand Chenier	9.90	New Orleans No. 2	1.38
Maryland—Delaware	68.3	+1.2	Western Port, Md	92	2	Grantsville, Md	28	16	3.51	+0.31	Cecilton, Md	7.27	Costen, Md	1.22
Michigan	59.9	+0.2	Webber Dam	92	5	Houghton Lake	24	15	3.23	+0.23	Bloomingdale	7.42	St. James	0.86
Minnesota	60.8	+2.4	Beardsley	98	4	Angus	19	13	2.31	−0.49	Grand Meadow	8.28	Little Falls	0.50
Mississippi	76.6	+0.4	5 stations	97	[2] 2	Port Gibson	51	24	2.15	−1.19	Cleveland	5.17	Lake	0.30
Missouri	68.7	−0.3	Caruthersville (2)	98	[2] 3	Unionville	33	14	4.59	+0.86	Downing	11.83	Patton	1 23
Montana	57.3	+2.1	Roy	102	5	Outlook	18	11	1.37	+0.02	Red Lodge	9.32	Harlowton	0.00
Nebraska	64.3	+0.4	4 stations	97	[2] 3	Nenzel	29	13	3.70	+1.56	Utica	11.06	Kimball	0.55
Nevada	63.0	+0.6	Beatty	112	8	Rye Patch	20	17	0.96	+0.48	Schurz	3.57	Mina	0.03
New England	61.2	+1.8	Lowell, Mass	90	[2] 1	3 stations	26	[2] 18	2.40	−1.16	Pittsburg, N. H.	5.87	Boston, Mass	0.38
New Jersey	67.0	+1.3	3 stations	90	[2] 1	Charlotteburg	28	18	3.78	+0.18	Cape May City	6.26	Little Falls	2.24
New Mexico	62.5	−1.8	Orogrande	100	3	2 stations	22	[2] 28	1.91	+0.29	Diener	6.74	Fort Sumner	0.08
New York	61.8	+0.9	4 stations	91	[2] 1	2 stations	24	17	3.54	+0.20	Walden	5.75	Ogdensburg	1.24
North Carolina	71.5	+1.7	Greenville	98	[2] 4	Wenona	36	18	3.96	+0.16	Neuse	7.82	Cullowhee	0.65
North Dakota	60.1	+3.7	Donnybrook	99	3	Hansboro	15	13	2.39	+0.75	New England	5.80	Powers Lake	0.23
Ohio	65.7	+0.3	Middleport	96	26	Canfield	24	15	3.12	+0.62	Pataskala	6.26	Green	0.75
Oklahoma	73.9	+0.2	Oakwood	103	12	Kenton	38	29	7.07	+4.21	Tuskahoma	14.43	Ardmore	2.23
Oregon	61.4	+2.7	2 stations	104	[2] 6	Lapine	12	19	0.91	−0.54	Siskiyou	3.53	Bend	0.05
Pennsylvania	64.8	+1.2	Lancaster	92	4	West Bingham	22	17	3.55	+0.32	Biglerville	8.68	Parkers Landing	1.54
Porto Rico	79.2	+0.3	3 stations	97	[2] 5	Albonito	56	20	5.54	−2.62	Lares	10.51	Santa Isabel	1.26
South Carolina	75.5	+1.2	Garnett	99	7	2 stations	50	[2] 14	2.67	−1.15	Wedgefield	9.62	Greenwood	0.44
South Dakota	62.4	+1.8	2 stations	100	4	Elk Mountain	22	17	3.24	+1.37	Vale	7.34	Britton	0.97
Tennessee	71.5	+0.4	Perryville	95	[2] 27	Rugby	38	[2] 15	2.57	−0.36	Covington	6.39	Copperhill	0.41
Texas	77.9	+0.8	Encinal	107	1	Clint	40	20	4.61	+1.79	Fort McIntosh	12.94	O 2 Ranch	0.30
Utah	59.0	−0.9	St. George	104	6	Loa	19	27	1.07	−0.08	Lower Mill Creek	3.27	Midlake	0.00
Virginia	68.7	+0.8	Danville	93	[2] 3	Burkes Garden	35	15	3.98	+0.80	Diamond Springs	7.30	Speers Ferry	1.55
Washington	60.6	+2.6	Trinidad	100	8	Wilbur	20	23	0.98	−0.69	Silverton	3.48	Rimrock	0.03
West Virginia	66.5	+0.8	Robertsburg	96	25	Terra Alta	29	10	3.31	+0.40	Organ Cave	5.36	Beckley	1.00
Wisconsin	59.8	+0.2	2 stations	90	[2] 5	7 stations	21	[2] 13	3.22	−0.28	Meadow Valley	7.22	Hayward	0.75
Wyoming	54.8	+0.1	2 stations	98	[2] 3	Riverside	11	[2] 18	3.43	+2.17	Verona	8.61	Gallatin	0.89

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385

[2] Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, September, 1923.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01, or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England.							61.7	+1.1										82	1.96	-1.2										5.5		
Eastport	76	67	85	30.02	30.10	+.07	54.9	-0.9	73	18	62	40	30	48	23	51	48	85	1.36	-1.6	10	5,252	s.	26	n.	17	6	13	11	6.1	0.0	0.0
Greenville, Me	1,070	6	....	28.95	30.11	.....	56.2	.....	77	24	66	32	20	46	37	.....	.....	.....	2.11	.....	10	.....	se.	.....	.....	.....	10	11	9	....	0.0	0.0
Portland, Me	103	82	117	30.01	30.13	+.08	60.3	+0.7	80	1	67	44	15	54	23	55	52	80	0.83	-2.4	11	5,182	s.	24	nw.	28	11	10	9	5.3	0.0	0.0
Concord	288	70	79	29.81	30.12	+.06	61.2	+1.9	87	1	72	32	15	50	42	.....	.....	.....	2.51	-0.7	12	2,667	se.	20	sw.	3	15	6	9	4.9	0.0	0.0
Burlington	404	11	48	29.66	30.09	+.03	59.6	+0.7	84	2	69	33	15	50	31	.....	.....	.....	3.74	+0.4	10	6,818	s.	36	s.	3	5	14	11	6.1	0.0	0.0
Northfield	876	12	60	29.18	30.12	+.06	57.0	+2.4	83	1	69	26	15	45	45	54	52	89	2.37	-0.4	11	4,704	s.	28	s.	7	4	10	16	7.0	0.0	0.0
Boston	125	115	188	29.97	30.11	+.04	64.2	+1.0	82	1	72	47	15	57	30	58	54	76	0.38	-2.8	6	5,572	e.	26	nw.	30	8	17	5	5.1	0.0	0.0
Nantucket	12	14	90	30.09	30.10	+.02	62.8	0.0	77	3	69	51	26	56	21	59	57	88	1.01	-1.7	6	8,755	se.	36	ne.	16	14	9	7	5.0	0.0	0.0
Block Island	26	11	46	30.08	30.11	+.03	63.9	+0.5	78	3	69	50	16	58	20	59	57	83	3.39	+0.4	7	8,869	sw.	36	nw.	30	14	6	10	4.7	0.0	0.0
Providence	160	215	251	29.94	30.11	+.04	63.6	+0.4	81	3	72	44	15	55	28	58	55	80	1.52	-1.6	8	6,740	nw.	34	nw.	30	6	19	5	5.4	0.0	0.0
Hartford	159	122	140	29.93	30.10	+.03	65.2	+3.5	86	1	74	40	15	56	34	59	56	79	2.39	-1.1	8	3,938	s.	21	s.	8	10	9	11	6.1	0.0	0.0
New Haven	106	74	153	30.00	30.11	+.04	65.6	+2.1	84	4	73	43	15	58	30	60	56	77	2.11	-1.7	6	5,568	n.	26	nw.	30	12	7	11	5.2	0.0	0.0
Middle Atlantic States.							67.9	+1.3										79	3.83	+0.4										5.2		
Albany	97	102	115	30.00	30.10	+.03	64.0	+0.9	85	1	72	40	15	56	30	58	56	81	4.01	+0.8	9	4,370	s.	26	s.	8	15	6	9	4.7	0.0	0.0
Binghamton	871	10	84	29.16	30.09	+.02	62.6	+2.6	87	1	72	35	15	53	39	.....	.....	.....	3.55	+0.8	12	2,878	e.	22	sw.	3	2	13	15	7.3	0.0	0.0
New York	314	414	454	29.78	30.11	+.03	67.0	+0.2	84	4	74	48	15	60	22	61	59	80	2.34	-1.2	7	8,843	n.	42	nw.	30	9	13	8	5.9	0.0	0.0
Harrisburg	374	94	104	29.72	30.12	+.04	67.2	+2.3	87	4	76	42	17	59	28	61	57	75	4.06	+1.2	12	3,450	ne.	26	ne.	30	8	10	12	5.4	0.0	0.0
Philadelphia	114	123	190	29.99	30.12	+.04	69.6	+1.6	85	4	77	50	16	62	20	62	57	71	3.64	+0.3	9	5,351	s.	29	ne.	30	9	13	8	5.3	0.0	0.0
Reading	325	81	98	29.77	30.11	.....	67.5	.....	86	4	76	42	17	59	29	62	60	80	3.34	-0.3	12	2,373	se.	13	se.	22	15	9	6	4.3	0.0	0.0
Scranton	805	111	119	29.26	30.12	+.05	64.0	+1.8	85	2	73	37	15	55	39	59	56	81	4.38	+1.5	12	3,496	n.	19	sw.	3	6	13	11	6.1	0.0	0.0
Atlantic City	52	37	172	30.05	30.10	+.03	68.2	+1.4	81	29	74	48	17	63	19	64	61	81	3.06	0.0	7	9,150	s.	34	s.	8	12	14	4	4.4	0.0	0.0
Cape May	17	13	49	30.12	30.14	+.07	69.0	0.0	82	25	75	46	17	63	24	64	62	84	6.26	+3.3	7	4,478	se.	20	se.	8	16	6	8	4.3	0.0	0.0
Sandy Hook	22	10	55	30.08	30.10	.....	68.2	.....	83	4	74	52	18	63	21	62	58	78	3.62	.....	7	8,331	s.	44	nw.	30	12	11	7	4.9	0.0	0.0
Trenton	190	159	183	29.90	30.10	.....	67.6	.....	84	4	76	46	17	59	27	61	58	77	4.19	+0.6	8	5,933	n.	47	nw.	12	9	12	9	5.5	0.0	0.0
Baltimore	123	100	113	29.97	30.10	+.02	70.4	+1.9	86	4	78	48	17	63	24	63	60	73	3.85	0.0	10	3,497	se.	17	ne.	30	10	10	10	5.3	0.0	0.0
Washington	112	62	85	29.98	30.10	+.02	69.6	+1.5	87	3	78	44	17	61	29	63	61	79	3.15	-0.4	12	2,934	n.	16	nw.	30	12	9	9	5.5	0.0	0.0
Cape Henry	18	8	54	30.06	30.08	.....	72.8	.....	89	21	78	52	18	67	22	67	64	79	4.15	+0.1	6	8,491	ne.	44	n.	30	9	14	7	5.5	0.0	0.0
Lynchburg	681	153	188	29.36	30.10	+.02	70.0	+1.0	90	4	80	45	18	60	30	63	60	81	2.84	-0.8	12	3,201	e.	24	nw.	29	7	15	8	5.1	0.0	0.0
Norfolk	91	170	205	30.00	30.10	+.04	73.6	+2.0	88	4	80	55	18	67	24	66	63	78	3.23	-0.8	7	7,335	ne.	35	n.	30	6	17	7	5.5	0.0	0.0
Richmond	144	11	52	29.96	30.10	+.03	70.8	0.0	87	4	80	48	18	62	27	64	62	82	4.25	+0.8	8	4,191	ne.	29	nw.	5	10	11	9	5.0	0.0	0.0
Wytheville	2,304	49	55	27.76	30.10	+.03	65.1	+1.5	84	6	75	43	17	55	31	59	58	86	4.84	+1.6	9	2,495	e.	20	sw.	7	13	15	2	4.0	0.0	0.0
South Atlantic States.							75.1	+1.7										81	3.64	-1.0										5.3		
Asheville	2,255	70	84	27.80	30.10	+.03	67.6	+2.6	83	5	78	48	16	58	30	61	59	84	2.64	-0.3	6	4,209	se.	37	se.	7	9	19	2	4.4	0.0	0.0
Charlotte	779	55	62	29.26	30.08	+.01	73.7	+2.2	91	7	83	53	16	64	25	65	63	77	2.32	-0.9	10	2,572	ne.	13	w.	6	6	16	8	5.7	0.0	0.0
Hatteras	11	11	50	30.06	30.07	+.01	74.8	+0.3	88	4	80	61	18	70	18	70	68	81	3.16	-2.2	8	8,310	ne.	37	n.	29	8	12	10	5.6	0.0	0.0
Manteo	12	5	42	.....	.....	.....	72.8	.....	92	4	.....	46	18	.....	30	.....	.....	.....	4.24	.....	5	.....	ne.	.....	.....	.....	13	4	13	.....	0.0	0.0
Raleigh	376	103	110	29.69	30.09	+.02	72.8	+2.2	91	4	82	52	16	64	24	66	64	83	6.35	+3.0	12	4,513	ne.	20	ne.	28	3	17	10	6.4	0.0	0.0
Wilmington	78	81	91	30.08	30.08	+.03	74.2	+1.1	89	5	81	56	18	67	26	69	66	85	7.20	+1.9	11	4,554	ne.	30	w.	12	7	19	4	5.0	0.0	0.0
Charleston	48	11	92	30.00	30.05	+.01	77.8	+1.2	95	6	84	62	16	71	20	72	70	82	2.11	-3.4	12	7,344	ne.	38	ne.	27	5	16	9	6.0	0.0	0.0
Columbia, S. C.	351	41	57	29.70	30.08	+.03	76.3	+2.6	94	6	85	57	16	68	25	68	66	81	3.13	-0.3	9	3,961	ne.	17	w.	4	10	13	7	4.8	0.0	0.0
Due West	711	10	55	29.34	30.10	.....	74.3	.....	92	6	84	55	16	64	28	.....	.....	.....	1.54	.....	8	4,833	ne.	21	ne.	27	12	7	11	5.4	0.0	0.0
Greenville, S. C.	1,039	113	122	28.99	30.07	.....	73.4	.....	89	6	82	54	16	65	26	66	62	76	1.41	.....	9	4,735	ne.	31	n.	24	14	13	3	4.0	0.0	0.0
Augusta	180	62	77	29.86	30.05	.00	77.4	+2.1	94	6	86	58	16	68	25	69	66	76	1.62	-2.1	4	3,452	e.	16	s.	3	7	14	9	5.3	0.0	0.0
Savannah	65	150	194	29.97	30.04	+.01	78.2	+2.0	95	6	86	63	16	71	23	71	70	83	2.94	-2.6	10	6,986	ne.	36	ne.	17	8	13	9	5.5	0.0	0.0
Jacksonville	43	209	245	29.97	30.02	+.02	78.6	+0.3	93	8	85	66	29	72	20	72	70	82	4.89	-3.1	14	7,378	e.	38	ne.	26	7	14	9	5.9	0.0	0.0
Florida Peninsula.							80.8	-0.4										79	5.94	-2.0										5.3		
Key West	22	10	64	29.94	29.96	+.02	82.3	+0.1	90	12	88	72	24	77	14	76	74	77	4.97	-1.8	16	5,458	e.	24	s.	17	10	17	3	4.6	0.0	0.0
Miami	25	71	79	29.96	29.99	.....	80.0	-1.5	88	27	85	69	13	74	17	75	73	80	6.21	-3.4	19	4,488	e.	21	nw.	26	7	14	9	5.8	0.0	0.0
Sand Key	23	39	72	29.94	29.97	+.03	81.0	.....	88	9	84	71	25	78	12	76	73	78	1.58	.....	16	7,468	e.	40	ne.	25	8	19	3	4.9	0.0	0.0
Tampa	35	79	87	29.96	29.99	+.02	80.0	+0.3	92	4	87	69	30	72	19	76	73	82	6.63	-0.8	16	3,579	ne.	25	ne.	15	2	21	7	5.9	0.0	0.0
East Gulf States.							77.3	+2.0										77	1.51	-2.4										4.2		
Atlanta	1,174	190	216	28.85	30.07	+.02	74.6	+2.2	88	6	83	57	16	66	22	67	64	74	0.54	-3.0	7	5,736	e.	26	e.	17	11	13	6	4.8	0.0	0.0
Macon	370	78	87	29.66	30.05	+.02	76.5	+3.6	94	6	86	59	29	67	27	69	66	79	5.08	+1.7	6	3,423	ne.	19	ne.	17	12	10	8	4.9	0.0	0.0
Thomasville	273	49	58	29.73	30.02	+.01	78.6	+1.8	95	7	88	62	29	70	25	71	69	81	2.32	-1.9	10	2,295	ne.	23	e.	7	6	11	13	6.0	0.0	0.0
Apalachicola	36	42	49	29.97	30.01	.....	78.7	.....	89	13	85	69	27	73	17	73	71	83	5.23	.....	10	4,646	n.	30	ne.	16	18	8	4	3.6	0.0	0.0
Pensacola	56	149	185	29.96	30.02	+.03	79.1	+1.1	91	13	86	64	23	72	19	72	70	76	1.66	-3.6	6	7,089	ne.	34	e.	10	11	15	4	4.1	0.0	0.0
Anniston	741	9	57	29.30	30.09	+.06	74.6	+3.3	90	5	87	54	14	63	33	.....	.....	.....	0.67	-2.9	6	2,876	n.	18	se.	17	17	12	1	2.9	0.0	0.0
Birmingham	700	11	48	29.32	30.07	+.04	75.8	+1.8	91	29	86	58	14	66	27	67	64	76	1.50	-2.0	3	3,410	n.	18	se.	17	12	14	4	3.9	0.0	0.0
Mobile	57	125	161	29.96	30.02	+.02	79.6	+1.7	91	12	88	63	23	71	24	72	69	79	0.47	-4.6	6	5,455	n.	28	se.	10	14	15	1	3.7	0.0	0.0
Montgomery	223	100	112	29.80	30.04	+.02	78.0	+1.7	92	6	87	62	22	69	26	69	66	72	0.12	-2.8	3	3,625	n.	20	e.	17	18	8	4	3.3	0.0	0.0
Corinth	469	6	.....	.....	.....	.....	74.6	.....	92	1	85	54	16	64	31	.....	.....	.....	3.88	.....	6	.....	se.	.....	.....	.....	6	22	2	.....	0.0	0.0
Meridian	375	85	93	29.65	30.04	+.02	75.9	+3.2	90	30	86	56	23	66	29	68	65	77	0.72	-2.8	4	2,811	ne.	28	sw.	5	16	12	2	3.6	0.0	0.0
Vicksburg	247	65	73	29.77	30.05	+.03	76.3	0.0	90	27	85	58	24	68	24	68	66	80	0.89	-2.4	5	3,646	se.	20	s.	16	11	12	7	4.8	0.0	0.0
New Orleans	53	76	84	29.96	30.01	+.03	81.2	+2.0	92	30	89	66	23	74	22	73	70	74	2.63	-2.2	10	3,689	se.	29	e.	10	13	14	3	4.4	0.0	0.0
West Gulf States.							76.9	+0.9										80	5.58	+2.1										5.3		
Shreveport	249	77	93	29.76	30.02	+.02	75.6	-0.1	90	28	84	59	23	68	24	69	67	83	9.03	+5.8	10	3,441	ne.	22	se.	17	18	3	9	4.1	0.0	0.0
Bentonville	1,303	11	44	.....	.....	.....	70.8	+1.9	91	10	81	51	22	61	32	.....	.....	.....	3.92	.....	12	.....	s.	.....	.....	.....	10	6	14	....	0.0	0.0
Fort Smith	457	79	94	29.53	30.00	-.01	73.9	+1.2	93	12	83	57	24	65	31	66	63	76	4.54	+1.4	12	4,622	e.	27	w.	20	7	13	10	5.4	0.0	0.0
Little Rock	357	136	144	29.66	30.03	.00	73.2	-0.9	90	29	81	57	15	65	28	67	65	82	3.93	+0.7	9	4,011	s.	30	nw.	19	7	7	16	6.2	0.0	0.0
Brownsville	57	53	61	29.87	29.93	.....	83.0	.....	95	4	90	72	23	76	21	75	73	82	4.55	.....	11	4,692	s.	22	s.	17	14	12	4	4.4	0.0	0.0
Corpus Christi	20	69	77	29.95	29.97	+.02	81.4	+2.4	92	1	86	70	15	76	18	76	74	83	6.35	+2.4	12	7,862	se.	44	ne.	20	6	9	15	6.6	0.0	0.0
Dallas	512	109	117	29.45	29.99	.....	78.2	.....	96	1	88	60	23	69	26	.....	.....	.....	3.14	.....	8	5,173	se.	44	se.	15	11	12	7	4.7	0.0	0.0
Fort Worth	670	106	114	29.26	29.96	-.03	78.5	+1.8	95	1	88	60	22	69	30	68	63	68	2.06	-0.9	4	5,728	e.	35	se.	15	11	13	6	4.9	0.0	0.0
Galveston	54	106	114	29.95	30.01	+.03	79.8	-0.3	88	2	84	68	15	75	18	75	73	84	9.91	+4.5	10	6,310	se.	33	se.	16	12	8	10	5.3	0.0	0.0
Groesbeck	461	11	56	29.51	29.98	.....	78.0	.....	94	1	88	59	22	68	27	.....	.....	.....	2.27	.....	7	5,369	se.	32	se.	16	7	16	7	5.4	0.0	0.0
Houston	138	111	121	29.85	29.99	.....	79.2	+0.7	94	1	87	63	22	71	22	.....	.....	.....	6.25	.....	11	4,179	s.	28	n.	20	7	13	10	5.3	0.0	0.0
Palestine	510	64	72	29.48	30.00	+.01	76.3	-0.7	95	2	84	59	22	68	23	69	67	80	6.22	+3.0	8	3,743	s.	34	s.	17	10	12	8	5.4	0.0	0.0
Port Arthur	34	58	66	29.96	30.00	.....	79.0	.....	90	12	86	63	22	72	20	73	71	81	6.60	.....	11	4,856	e.	26	se.	16	14	7	9	4.5	0.0	0.0
San Antonio	693	119	132	29.27	29.97	+.01	79.2	+2.1	93	3	88	62	21	71	25	71	68	78	2.98	0.0	10	4,505	se.	28	n.	20	7	13	10	6.0	0.0	0.0
Taylor	583	55	63	29.40	30.01	+.04	78.4	+1.5	94	3	87	60	22	70	23	.....	.....	.....	5.19	+2.2	10	4,263	se.	28	se.	15	6	14	10	6.0	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, September, 1923*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01, or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee.							**69.3**	**+0.8**										**78**	**2.66**	**−0.1**										**5.4**		
Chattanooga	762	189	213	29.28	30.08	+.02	73.2	+1.0	87	12	83	55	16	64	28	65	61	74	2.90	−0.4	8	3,658	n.	44	s.	20	10	14	6	4.6	0.0	0.0
Knoxville	996	102	111	29.04	30.08	+.02	72.4	+1.8	89	4	83	50	15	62	29	64	61	77	1.50	−1.3	7	3,275	n.	25	w.	6	16	9	5	3.6	0.0	0.0
Memphis	399	76	97	29.62	30.04	+.01	73.8	+0.2	89	27	81	57	14	66	25	68	66	82	5.47	+2.4	10	3,834	sw.	26	sw.	20	12	6	12	5.2	0.0	0.0
Nashville	546	168	191	29.50	30.08	+.02	71.8	0.0	88	26	81	48	16	63	28	64	61	76	1.44	−2.2	6	4,732	nw.	26	sw.	4	11	9	10	5.3	0.0	0.0
Lexington	989	193	230	29.04	30.09	+.02	69.0	+1.1	88	1	78	41	14	60	27	....	....	....	1.51	−0.9	10	7,787	sw.	34	sw.	6	9	12	9	5.3	0.0	0.0
Louisville	525	219	255	29.51	30.09	+.03	70.8	+0.3	89	1	80	45	14	62	28	62	58	71	3.61	+1.0	10	6,298	s.	43	n.	28	11	9	10	5.0	0.0	0.0
Evansville	431	139	175	29.61	30.07	+.01	70.8	+1.1	92	28	80	46	15	62	28	63	59	73	1.84	−0.8	7	6,218	sw.	30	sw.	20	7	15	8	5.7	0.0	0.0
Indianapolis	822	194	230	29.20	30.08	+.02	67.0	+0.1	86	27	75	42	14	59	26	60	57	76	3.91	+0.9	8	6,355	s.	28	w.	7	7	12	11	6.1	0.0	0.0
Royal Center	736	11	55	29.28	30.08	....	64.4	....	85	27	74	33	14	54	31	....	....	....	3.24	....	11	5,127	s.	25	w.	8	3	11	16	7.1	0.0	0.0
Terre Haute	575	96	129	29.45	30.06	....	67.2	....	86	28	76	39	14	59	25	61	58	78	3.40	....	10	5,161	s.	40	n.	28	3	13	14	6.8	0.0	0.0
Cincinnati	628	11	51	29.41	30.08	+.01	68.3	+1.2	90	27	78	39	14	58	32	....	61	81	1.40	−0.9	8	3,791	ne.	19	se.	20	10	11	9	5.0	0.0	0.0
Columbus	824	179	222	29.23	30.10	+.03	66.9	+0.4	88	1	76	39	14	58	29	60	56	76	3.39	+0.9	10	5,930	s.	28	w.	27	10	10	10	5.4	0.0	0.0
Dayton	899	137	173	29.13	30.08	....	67.0	−0.4	87	1	76	37	14	58	32	60	57	76	3.45	+1.0	8	4,795	ne.	40	sw.	27	13	11	6	4.6	0.0	0.0
Elkins	1,947	59	67	28.10	30.13	+.05	63.6	+1.7	86	26	76	35	16	52	37	57	55	89	2.33	−0.5	9	2,167	w.	17	nw.	30	10	10	10	5.3	0.0	0.0
Parkersburg	638	77	84	29.46	30.11	+.03	68.4	+2.3	88	1	78	41	16	58	31	61	58	80	2.92	+0.2	11	2,629	se.	15	n.	30	13	9	8	5.0	0.0	0.0
Pittsburgh	842	353	410	29.20	30.10	+.02	67.4	+1.0	87	1	76	42	16	59	30	60	57	76	1.62	−0.9	8	5,586	nw.	31	w.	13	8	10	12	5.8	0.0	0.0
Lower Lake Region.							**63.3**	**+0.4**										**77**	**2.87**	**0.0**										**6.2**		
Buffalo	767	247	280	29.28	30.10	+.04	62.9	+0.5	85	26	70	40	14	56	25	57	53	74	1.86	−1.3	9	8,495	sw.	56	w.	8	4	18	8	6.0	0.0	0.0
Canton	448	10	61	29.59	30.06	....	59.4	+0.1	87	2	70	30	17	49	33	....	....	....	2.10	−0.7	10	5,437	sw.	32	w.	13	12	6	12	5.5	0.0	0.0
Oswego	335	76	91	....	30.09	+.03	61.5	+0.3	88	2	69	42	17	59	29	....	....	78	2.75	−0.1	15	5,598	s.	32	n.	29	8	7	15	....	T.	0.0
Rochester	523	86	102	29.54	30.10	+.04	62.2	+0.2	88	2	70	38	17	54	32	56	53	76	3.35	+1.0	11	4,202	sw.	28	sw.	27	4	11	15	7.0	0.0	0.0
Syracuse	597	97	113	29.46	30.11	+.04	62.2	+0.6	86	2	70	38	17	54	28	....	....	....	2.94	+0.1	12	5,909	s.	32	s.	8	4	9	17	6.9	0.0	0.0
Erie	714	130	166	29.32	30.09	+.03	64.9	+1.3	86	2	71	44	16	58	23	59	55	74	3.52	0.0	14	7,836	n.	38	w.	8	8	15	7	5.7	0.0	0.0
Cleveland	762	190	201	29.28	30.10	+.04	64.7	+0.8	85	26	70	41	15	59	28	59	55	76	3.32	+0.1	11	7,433	s.	36	ne.	29	3	15	12	6.9	0.0	0.0
Sandusky	629	62	70	29.41	30.09	+.03	65.2	−0.1	88	2	72	41	15	58	25	....	....	....	3.26	+0.6	15	4,483	sw.	27	nw.	8	3	15	12	6.8	0.0	0.0
Toledo	628	208	243	29.42	30.10	+.04	64.6	+0.2	86	27	72	40	14	57	25	59	56	79	3.69	+1.3	11	7,206	sw.	31	w.	2	15	8	7	4.8	0.0	0.0
Fort Wayne	856	113	124	29.17	30.09	....	65.0	−0.5	86	27	74	40	15	56	34	59	56	79	2.41	....	10	4,408	e.	22	sw.	6	5	15	10	6.0	0.0	0.0
Detroit	730	218	258	29.30	30.09	+.03	64.0	+0.5	85	27	71	40	14	57	20	59	56	80	1.90	−0.6	13	5,972	sw.	31	sw.	7	6	14	10	6.3	0.0	0.0
Upper Lake Region.							**59.5**	**+0.2**										**83**	**3.26**	**+0.1**										**6.0**		
Alpena	609	13	92	29.44	30.11	+.08	56.4	−0.9	79	2	64	34	13	48	27	54	52	87	1.65	−1.8	12	6,476	se.	38	nw.	12	9	10	11	5.9	T.	0.0
Escanaba	612	54	60	29.42	30.08	+.07	55.8	−1.1	71	5	63	32	13	49	26	53	51	87	2.34	−1.2	12	5,956	s.	30	nw.	12	11	10	9	5.0	T.	0.0
Grand Haven	632	54	89	29.39	30.06	+.02	61.0	+0.1	84	1	69	37	16	53	29	57	54	82	3.42	+0.2	12	6,056	w.	35	sw.	12	10	10	10	5.7	0.0	0.0
Grand Rapids	707	70	87	29.32	30.09	+.04	63.0	+1.2	86	5	72	42	13	54	27	57	54	79	5.77	+2.6	10	3,206	e.	20	w.	12	5	13	12	6.6	0.0	0.0
Houghton	668	62	99	29.32	30.05	+.05	57.0	+0.9	84	26	66	36	13	48	31	....	....	....	3.83	+0.3	10	5,702	e.	37	w.	12	8	9	13	6.0	0.5	0.0
Lansing	878	11	62	29.15	30.09	....	62.1	+0.8	86	5	72	36	16	52	31	56	55	88	5.61	+3.0	11	2,558	sw.	15	sw.	2	3	15	12	6.6	0.0	0.0
Ludington	637	60	66	29.38	30.08	....	58.8	....	78	1	66	36	15	51	25	55	52	84	2.53	....	11	5,855	e.	33	w.	12	10	12	8	5.0	0.0	0.0
Marquette	734	77	111	29.29	30.09	+.09	56.8	0.0	83	26	65	36	13	49	30	52	49	80	1.63	−1.9	10	6,997	nw.	36	w.	12	6	10	14	6.6	0.2	0.0
Port Huron	638	70	120	29.39	30.08	+.02	61.6	0.0	85	27	69	34	14	54	25	57	54	80	3.87	+1.2	10	6,390	ne.	33	w.	8	5	15	10	6.0	0.0	0.0
Saginaw	641	69	77	29.40	30.10	....	61.1	....	84	5	70	39	13	52	27	57	55	86	3.01	−0.1	10	4,511	ne.	24	sw.	2	5	14	11	6.4	0.0	0.0
Sault Sainte Marie	614	11	52	29.40	30.10	+.08	56.1	+1.8	76	27	65	34	15	47	29	52	50	88	2.63	−0.8	10	4,547	nw.	30	nw.	13	6	11	13	6.4	0.3	0.0
Chicago	823	140	310	29.19	30.08	+.04	65.1	−1.2	80	27	70	42	14	60	17	60	57	78	2.50	−0.5	11	6,828	s.	30	s.	1	5	17	8	5.7	0.0	0.0
Green Bay	617	109	144	29.40	30.06	+.04	59.8	+0.7	81	27	68	34	14	52	27	54	51	81	1.48	−1.6	9	6,821	s.	34	ne.	20	2	14	14	7.2	0.0	0.0
Milwaukee	681	125	139	29.34	30.07	+.04	61.8	−0.7	81	2	68	38	14	56	20	57	54	81	5.22	+2.3	11	6,241	ne.	35	e.	6	6	13	11	6.2	0.0	0.0
Duluth	1,133	11	47	28.82	30.04	+.06	56.4	+1.3	81	27	64	30	13	48	29	50	47	79	2.61	−0.9	9	8,081	ne.	32	nw.	12	10	11	9	4.9	T.	0.0
North Dakota.							**59.8**	**+2.7**										**66**	**2.18**	**+0.7**										**5.3**		
Moorhead	940	50	58	28.96	29.97	+.01	60.6	+2.4	84	23	72	27	13	49	38	53	48	69	1.68	−0.6	8	6,027	s.	30	nw.	6	9	11	10	5.6	0.0	0.0
Bismarck	1,674	8	57	28.22	29.99	+.05	61.0	+2.9	94	3	73	34	13	49	39	52	46	66	2.83	+1.6	11	6,392	n.	26	n.	17	11	6	13	5.7	0.0	0.0
Devils Lake	1,478	11	44	28.39	29.95	+.01	58.2	+2.6	90	1	70	25	13	46	38	51	46	72	1.63	+0.2	8	7,133	s.	35	sw.	5	13	5	12	5.1	0.0	0.0
Ellendale	1,457	10	56	28.42	29.98	....	60.5	....	90	5	73	34	13	48	45	....	....	....	1.11	....	7	9,422	s.	40	se.	24	12	10	8	4.6	0.0	0.0
Grand Forks	835	12	89	....	....	....	59.0	....	87	15	71	24	13	47	42	....	....	....	2.22	....	7	....	se.	30	se.	24	14	2	14	....	0.0	0.0
Williston	1,878	41	48	27.99	29.95	+.02	59.6	+3.0	97	3	72	27	12	47	42	49	41	59	2.60	+1.7	6	5,745	n.	29	se.	5	8	12	10	5.6	0.0	0.0
Upper Mississippi Valley.							**65.2**	**−0.3**										**80**	**4.23**	**+0.9**										**6.1**		
Minneapolis	918	102	208	29.02	30.00	....	63.1	....	88	4	73	34	13	54	28	....	....	....	1.61	−2.0	12	7,684	s.	34	nw.	11	8	8	14	5.9	0.0	0.0
St. Paul	837	236	261	29.12	30.02	+.03	62.4	+1.1	87	5	72	33	13	53	28	....	....	....	1.10	−2.3	11	8,321	se.	43	se.	16	8	17	5	5.1	0.0	0.0
La Crosse	714	11	48	29.28	30.04	+.03	62.2	0.0	86	5	72	31	14	53	30	....	....	....	4.00	−0.1	7	2,803	se.	15	s.	25	6	12	12	6.5	0.0	0.0
Madison	974	70	78	29.03	30.07	+.04	61.7	−0.7	85	5	69	39	14	54	24	56	53	80	4.36	+1.2	10	4,984	s.	34	ne.	20	4	12	14	6.7	0.0	0.0
Wausau	1,247	4	....	28.75	30.09	....	58.0	....	82	26	68	27	14	48	33	....	....	....	3.57	....	8	....	se.	....	....	....	12	6	12	5.3	0.0	0.0
Charles City	1,015	10	49	28.97	30.04	+.04	62.4	+0.7	87	5	72	33	14	52	29	56	54	81	7.12	+4.3	10	3,985	se.	24	se.	16	9	12	9	5.4	0.0	0.0
Davenport	606	71	79	29.39	30.05	+.02	65.6	0.0	87	4	75	40	14	57	28	59	56	77	4.53	+1.4	11	4,018	e.	23	nw.	11	7	8	15	6.2	0.0	0.0
Des Moines	861	84	97	29.11	30.01	−.01	65.2	−0.4	87	3	74	39	14	56	29	60	58	83	5.17	+2.1	12	4,089	se.	28	s.	26	9	11	10	5.9	0.0	0.0
Dubuque	698	81	96	29.33	30.08	+.05	62.8	−1.2	86	5	71	35	14	54	27	57	54	81	5.04	+1.4	10	3,234	s.	19	se.	16	6	10	14	6.6	0.0	0.0
Keokuk	614	64	78	29.37	30.04	+.01	67.1	−0.4	88	4	76	40	14	58	29	60	56	74	4.64	+0.7	12	4,293	se.	26	sw.	8	8	6	16	6.3	0.0	0.0
Cairo	358	87	93	29.67	30.04	−.01	70.6	−0.9	90	28	78	50	16	63	24	64	62	82	3.48	+1.0	9	4,577	s.	26	sw.	20	6	8	16	6.6	0.0	0.0
Peoria	636	11	45	29.41	30.07	+.03	65.4	+1.1	86	3	75	37	14	55	30	60	58	84	5.28	+2.2	12	2,783	se.	15	sw.	8	8	10	12	5.8	0.0	0.0
Springfield, Ill	644	10	91	29.36	30.03	−.02	66.4	−1.2	83	4	74	39	14	58	28	61	58	83	5.66	+2.3	9	4,727	se.	21	s.	26	7	9	14	6.0	0.0	0.0
Hannibal	534	74	109	29.46	30.03	.00	67.4	−0.3	87	28	76	43	14	58	32	....	....	....	3.69	+0.1	13	4,897	e.	27	sw.	8	6	12	12	6.1	0.0	0.0
St. Louis	568	265	303	29.43	30.04	.00	69.0	−1.1	88	28	77	47	14	62	23	62	59	77	3.51	+0.6	13	7,220	s.	32	sw.	20	7	6	17	6.5	0.0	0.0
Missouri Valley.							**67.1**	**+1.5**										**72**	**4.84**	**+2.2**										**4.9**		
Columbia, Mo	784	11	84	29.19	30.01	−.02	68.2	+0.4	88	28	78	44	22	59	32	....	....	....	3.03	+0.2	11	4,274	se.	24	nw.	25	8	12	10	5.7	0.0	0.0
Kansas City	963	161	181	28.98	30.00	−.02	69.2	+1.7	89	3	78	49	14	61	27	62	58	73	9.61	+5.8	12	6,151	se.	41	nw.	6	11	13	6	4.8	0.0	0.0
St. Joseph	967	11	49	28.96	29.99	....	68.6	....	92	3	78	45	14	59	29	61	58	78	5.02	....	12	4,844	se.	33	nw.	29	12	10	8	4.7	0.0	0.0
Springfield, Mo	1,324	98	104	28.64	30.03	.00	69.2	+1.3	88	10	78	52	22	61	27	62	59	75	3.82	+0.1	12	6,386	se.	26	se.	16	11	12	7	4.8	0.0	0.0
Iola	984	11	50	28.96	29.98	−.05	71.9	+3.3	98	10	83	49	22	61	41	....	....	....	4.23	+0.9	13	3,920	se.	22	ne.	11	6	10	14	6.2	0.0	0.0
Topeka	987	92	107	....	....	....	69.8	+1.5	92	3	80	49	21	60	35	....	....	....	2.43	−1.1	10	5,975	s.	34	e.	5	10	11	9	4.8	0.0	0.0
Drexel	1,299	10	54	28.61	29.98	....	65.6	....	91	4	76	38	14	55	31	....	....	....	8.24	....	11	6,039	se.	34	e.	28	8	16	6	5.2	0.0	0.0
Lincoln	1,189	11	84	28.74	29.98	−.01	67.6	+2.4	92	4	78	42	14	57	33	59	55	72	7.21	+4.6	9	6,202	se.	38	nw.	28	5	14	11	6.0	0.0	0.0
Omaha	1,105	115	122	28.83	30.00	.00	67.4	+0.6	92	4	76	44	14	58	28	59	55	73	9.32	+6.3	12	4,911	se.	36	n.	28	10	11	9	5.0	0.0	0.0
Valentine	2,598	47	54	27.29	29.98	+.02	62.8	+0.3	92	4	76	37	13	50	40	53	47	67	1.94	+0.2	10	6,354	w.	39	n.	1	14	11	5	3.7	0.0	0.0
Sioux City	1,135	94	164	28.80	30.00	+.02	65.3	+1.9	90	4	75	42	14	56	31	58	53	72	7.36	+4.9	11	8,045	s.	40	se.	24	10	13	7	4.8	0.0	0.0
Huron	1,306	59	74	28.61	30.00	+.04	64.0	+2.7	96	4	76	38	14	52	40	55	50	70	1.95	+0.3	10	6,756	se.	30	nw.	8	13	11	6	4.4	0.0	0.0
Pierre	1,572	70	75	28.31	29.96	+.01	64.4	+0.6	94	5	78	35	13	51	42	54	49	66	1.21	+0.1	8	6,216	e.	40	w.	25	17	6	7	3.9	0.0	0.0
Yankton	1,233	49	57	28.67	29.97	−.01	65.4	+1.4	92	4	76	43	13	55	34	....	....	....	6.01	+3.6	9	4,984	se.	36	se.	28	11	11	8	4.8	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, September, 1923*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope.							58.2	+1.0										60	2.27	+1.1										4.2		
Billings	3,140	5	....	.....	.....	.....	60.0	.....	94	3	76	32	12	44	52	.....	.....	.....	4.84	.....	8	.....	sw.	.....		.....	13	8	9	....	0.0	0.0
Havre	2,505	11	44	27.39	30.01	+.07	57.8	+1.4	89	2	74	30	28	42	49	48	41	61	0.50	−0.5	7	3,538	sw.	37	nw.	5	15	8	7	4.0	0.0	0.0
Helena	4,110	87	112	25.86	30.01	+.04	58.2	+1.6	87	2	71	36	23	46	38	46	34	46	0.16	−0.9	2	5,394	sw.	31	n.	16	16	5	9	3.9	0.0	0.0
Kalispell	2,973	48	56	26.97	30.00	+.04	57.0	+3.1	83	4	72	31	17	42	41	46	36	52	0.23	−1.1	3	4,014	nw.	36	nw.	15	21	6	3	2.9	0.0	0.0
Miles City	2,371	48	55	27.50	30.03	+.08	62.3	+1.1	99	3	74	38	18	50	42	50	42	56	4.26	+3.3	8	4,157	n.	29	n.	9	15	5	10	4.2	0.0	0.0
Rapid City	3,259	50	58	26.63	30.01	+.05	60.5	+1.4	90	3	72	34	18	49	42	50	42	56	4.90	+3.6	9	5,333	w.	42	nw.	5	16	6	8	4.4	0.0	0.0
Cheyenne	6,088	84	101	24.08	29.98	+.02	55.8	−1.2	82	9	68	35	7	44	38	46	39	61	2.78	+1.8	10	7,346	w.	46	w.	27	13	11	6	4.6	0.0	0.0
Lander	5,372	60	68	24.72	30.02	+.06	56.4	+1.2	86	3	70	31	18	43	40	46	39	61	5.64	+4.6	6	3,469	sw.	32	w.	4	11	11	8	4.9	T.	0.0
Sheridan	3,790	10	47	26.16	30.04	.....	56.6	.....	92	3	71	30	18	42	45	48	44	73	8.18	.....	8	3,657	nw.	42	nw.	5	16	6	8	4.3	0.0	0.0
Yellowstone Park	6,200	11	48	23.97	30.03	+.06	52.3	−1.1	81	8	67	25	18	38	44	42	34	58	1.05	0.0	6	5,669	s.	33	s.	22	12	11	7	4.5	0.0	0.0
North Platte	2,821	11	51	27.12	30.02	+.05	63.8	+1.7	91	3	77	40	29	51	40	54	50	72	0.88	−0.6	6	4,272	se.	32	e.	27	16	8	6	3.8	0.0	0.0
Middle Slope.							68.1	+0.3										67	3.52	+1.6										4.5		
Denver	5,292	106	113	24.79	30.00	+.04	60.6	−2.3	86	9	72	40	29	49	32	49	42	58	0.75	−0.1	5	4,737	s.	29	n.	6	13	13	4	4.2	0.0	0.0
Pueblo	4,685	80	86	25.34	29.97	+.01	63.0	−1.4	89	9	76	35	29	50	40	51	44	58	1.36	+0.7	7	3,929	nw.	32	s.	23	16	10	4	3.8	0.0	0.0
Concordia	1,392	50	58	28.52	29.97	−.02	69.6	+1.5	92	4	80	48	21	59	33	60	55	70	2.94	+0.4	9	4,962	s.	24	se.	24	7	14	9	5.8	0.0	0.0
Dodge City	2,509	11	51	27.43	30.00	+.02	69.6	+0.2	92	10	82	47	20	58	36	59	54	71	2.50	+0.7	12	6,489	se.	30	se.	16	19	6	5	3.2	0.0	0.0
Wichita	1,358	139	158	28.55	29.96	−.04	71.8	+2.0	94	10	81	51	21	62	32	63	58	70	3.26	+0.1	14	8,544	s.	35	w.	29	10	12	8	5.1	0.0	0.0
Broken Arrow	765	11	52	29.20	30.02	.....	73.0	.....	94	10	82	55	21	64	33	.....	.....	.....	4.26	.....	12	7,691	se.	33	se.	18	12	8	10	5.0	0.0	0.0
Muskogee	652	4	....	.....	.....	.....	75.0	.....	98	10	87	52	8	63	40	.....	.....	.....	5.41	.....	10	.....	se.	.....		.....	12	12	6	....	0.0	0.0
Oklahoma City	1,214	10	47	28.73	29.98	−.01	74.0	+1.9	93	9	83	55	22	65	29	65	62	76	10.28	+7.5	13	6,549	s.	48	nw.	18	16	7	7	4.1	0.0	0.0
Southern Slope.							74.2	+1.4										63	3.88	+1.4										3.8		
Abilene	1,738	10	52	28.18	29.95	−.01	77.2	+3.0	96	1	88	57	21	66	31	66	61	67	1.10	−2.0	5	6,196	s.	29	s.	27	10	11	9	5.2	0.0	0.0
Amarillo	3,676	10	49	26.32	29.99	+.03	69.8	+2.1	90	11	82	52	25	58	32	59	55	69	6.42	+4.1	11	6,164	se.	32	ne.	3	18	10	2	3.6	0.0	0.0
Del Rio	944	64	71	28.96	29.93	−.01	79.6	+0.7	97	1	88	61	21	72	26	.....	.....	.....	2.27	−0.2	8	6,276	se.	36	e.	20	5	6	19	3.7	0.0	0.0
Roswell	3,566	75	85	26.38	29.92	.00	70.3	0.0	92	26	84	50	29	57	40	56	47	54	5.74	+3.9	6	4,556	s.	30	nw.	14	19	10	1	2.5	0.0	0.0
Southern Plateau.							69.4	−1.2										50	0.84	0.0										2.4		
El Paso	3,762	110	133	26.19	29.88	.00	73.5	+0.8	90	4	85	54	29	62	32	58	48	48	0.41	−1.0	3	5,994	se.	38	nw.	14	21	9	0	2.5	0.0	0.0
Santa Fe	7,013	38	53	23.35	29.95	+.02	58.6	−2.3	78	10	70	36	28	47	28	47	39	58	1.10	−0.5	10	3,921	e.	25	sw.	27	15	10	5	3.7	0.0	0.0
Flagstaff	6,907	10	59	23.42	29.94	+.05	53.4	−2.1	84	7	68	24	28	39	42	45	.....	64	3.37	.....	8	5,177	w.	38	se.	23	12	13	5	....	0.0	0.0
Phoenix	1,108	11	81	28.70	29.83	+.02	80.2	−1.2	105	5	94	50	28	66	38	63	53	45	0.97	0.0	3	3,398	e.	28	nw.	12	21	9	0	1.6	0.0	0.0
Yuma	141	9	54	29.67	29.82	+.04	81.6	−2.1	110	5	96	52	27	67	39	67	58	52	1.54	+1.4	3	2,315	sw.	27	se.	10	27	2	1	1.2	0.0	0.0
Independence	3,957	5	25	25.99	29.97	+.11	68.9	−0.2	98	8	83	37	24	55	37	52	35	32	0.20	+0.1	2	6,275	nw.	37	w.	25	19	10	1	2.9	0.0	0.0
Middle Plateau.							61.9	−0.1										46	0.88	+0.2										3.8		
Reno	4,532	74	81	25.50	29.96	+.01	62.7	+3.0	95	7	78	32	24	48	39	48	38	50	0.48	+0.2	5	4,106	w.	33	w.	2	18	7	5	3.2	0.0	0.0
Tonopah	6,090	12	20	24.10	29.93	.....	61.6	.....	88	8	71	32	23	52	25	46	30	36	1.09	+0.6	6	6,360	w.	36	nw.	26	19	9	2	3.3	T.	0.0
Winnemucca	4,344	18	56	25.64	29.99	+.06	60.4	+1.2	95	8	77	30	18	44	50	47	37	53	1.16	+0.8	7	3,958	sw.	25	ne.	17	17	3	10	3.9	0.0	0.0
Modena	5,479	10	43	24.65	29.95	+.03	58.2	−2.0	91	9	75	26	27	42	47	44	30	43	0.46	−0.7	6	6,434	w.	45	sw.	22	14	13	3	3.8	0.7	0.0
Salt Lake City	4,360	163	203	25.64	29.96	+.01	64.2	−0.2	91	10	75	36	27	53	32	50	38	43	1.41	+0.6	5	5,295	se.	42	s.	23	14	7	9	4.5	0.0	0.0
Grand Junction	4,602	60	68	25.42	29.97	+.02	64.0	−2.4	92	9	77	40	27	51	36	51	42	51	0.71	−0.2	5	4,197	se.	38	se.	4	14	9	7	4.1	0.0	0.0
Northern Plateau.							63.9	+2.6										46	0.40	−0.4										3.4		
Baker	3,471	48	53	26.47	30.02	+.03	59.5	+2.5	90	2	74	35	18	45	44	48	37	50	0.36	−0.4	3	4,329	se.	25	nw.	26	16	6	8	4.1	0.0	0.0
Boise	2,739	78	86	27.15	29.97	.00	65.7	+3.8	97	2	80	41	27	52	36	52	40	44	0.55	+0.1	3	3,019	se.	20	nw.	24	21	5	4	2.8	0.0	0.0
Lewiston	757	40	48	29.20	30.00	+.02	66.4	+2.9	98	2	83	39	23	49	47	.....	.....	.....	0.10	−0.6	1	1,827	w.	27	n.	15	20	4	6	3.2	0.0	0.0
Pocatello	4,477	60	68	25.49	29.95	−.01	62.6	+1.9	90	8	76	35	27	49	41	47	34	43	0.86	0.0	3	6,149	se.	38	sw.	24	15	6	9	4.5	0.0	0.0
Spokane	1,929	101	110	27.98	30.00	+.02	62.3	+3.1	88	13	77	39	22	48	43	50	39	50	0.31	−0.7	3	2,860	sw.	23	nw.	15	17	6	7	3.3	0.0	0.0
Walla Walla	991	57	65	28.93	29.99	−.01	67.1	+1.7	93	8	79	44	22	55	37	53	41	44	0.21	−0.7	2	2,598	s.	13	w.	15	22	2	6	2.7	0.0	0.0
North Pacific Coast region.							60.4	+2.2										78	1.43	−1.0										4.5		
North Head	211	11	56	29.83	30.05	+.02	58.3	+2.1	82	30	63	49	22	54	21	56	54	87	2.05	+0.2	7	8,364	n.	68	s.	23	9	8	13	6.2	0.0	0.0
Port Angeles	29	8	53	.....	30.07	.....	56.2	.....	78	10	65	38	23	47	32	.....	.....	.....	1.47	−0.4	6	3,834	s.	24	w.	2	19	4	7	....	0.0	0.0
Seattle	125	215	250	29.94	30.07	+.06	60.8	+2.9	83	7	68	46	28	53	26	55	50	73	1.37	−0.4	5	4,167	n.	27	sw.	2	15	8	7	4.4	0.0	0.0
Tacoma	213	113	120	29.84	30.05	+.03	59.8	+2.2	81	7	68	44	28	51	27	.....	.....	.....	1.16	−1.3	4	3,839	n.	30	s.	24	8	14	8	5.5	0.0	0.0
Tatoosh Island	86	9	57	29.95	30.05	+.03	54.8	+1.8	70	7	60	45	22	50	16	54	53	94	1.74	−4.4	8	7,994	s.	46	e.	30	8	10	12	5.8	0.0	0.0
Yakima	1,071	5	....	.....	.....	.....	64.0	.....	94	8	81	33	23	47	49	.....	.....	.....	0.86	.....	2	.....	nw.	.....		.....	17	7	6	3.6	0.0	0.0
Medford	1,425	4	....	.....	.....	.....	67.0	.....	104	6	86	39	27	48	54	.....	.....	.....	0.99	.....	5	.....	se.	.....		.....	19	2	9	2.8	0.0	0.0
Portland, Oreg.	153	68	106	29.86	30.02	−.01	64.5	+2.8	95	7	75	45	27	54	32	57	52	68	0.59	−1.2	4	3,502	nw.	19	e.	30	14	8	8	4.2	0.0	0.0
Roseburg	510	9	57	29.47	30.01	−.01	64.3	+1.4	100	7	78	44	18	50	47	55	48	66	1.63	+0.6	5	1,901	n.	18	n.	15	17	7	6	3.8	0.0	0.0
Middle Pacific Coast region.							65.6	+2.5										65	1.25	+0.7										3.6		
Eureka	62	73	89	29.96	30.03	+.02	57.2	+2.3	70	17	62	47	16	52	22	54	53	88	1.54	+0.4	3	3,721	n.	35	n.	16	10	8	12	5.9	0.0	0.0
Point Reyes	490	7	18	29.41	29.93	.....	57.4	+1.3	87	17	62	48	11	52	31	.....	.....	.....	0.82	.....	3	11,962	nw.	48	n.	17	8	4	18	6.7	0.0	0.0
Red Bluff	332	50	56	29.55	29.89	−.04	75.0	+1.9	108	7	88	43	26	61	39	59	46	43	3.13	+2.3	4	3,502	se.	28	nw.	16	25	1	4	1.9	0.0	0.0
Sacramento	69	106	117	29.83	29.90	+.01	72.7	+3.4	107	7	86	46	26	59	38	60	50	53	0.50	+0.1	5	5,359	s.	31	n.	17	24	5	1	1.9	0.0	0.0
San Francisco	155	208	243	29.78	29.95	+.01	64.0	+3.1	87	5	72	52	10	56	31	57	53	76	0.44	+0.2	3	6,303	sw.	46	n.	17	21	5	4	3.1	0.0	0.0
San Jose	141	12	110	29.79	29.94	.....	67.5	+2.8	100	6	82	45	27	53	42	.....	.....	.....	0.62	+0.3	2	3,906	nw.	24	nw.	17	23	4	3	2.4	0.0	0.0
South Pacific Coast region.							70.2	+2.2										68	0.38	+0.2										3.0		
Fresno	327	89	98	29.54	29.89	+.02	76.4	+2.1	107	7	90	46	27	63	34	60	47	41	0.25	0.0	3	4,530	nw.	26	nw.	26	24	4	2	1.7	0.0	0.0
Los Angeles	338	159	191	29.57	29.93	+.05	70.4	+1.4	92	4	79	54	23	61	27	62	59	76	0.55	+0.5	3	3,614	sw.	18	nw.	26	15	5	10	4.1	0.0	0.0
San Diego	87	62	70	29.83	29.92	+.03	68.4	+1.1	85	5	74	53	27	62	22	63	61	81	0.03	0.0	2	4,251	nw.	20	nw.	20	17	7	6	3.6	0.0	0.0
San Luis Obispo	201	32	40	29.74	29.96	+.03	65.8	+4.3	96	6	79	44	24	53	39	56	52	72	0.70	+0.2	3	2,370	nw.	15	nw.	21	22	6	2	2.6	0.0	0.0
West Indies.																																
San Juan, P. R.	82	9	54	29.88	29.96	.....	80.0	−0.5	90	15	85	73	28	75	15	.....	.....	.....	6.65	−0.2	13	7,504	e.	34	e.	7	7	19	4	4.9	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.71	29.83	−.01	80.6	+0.8	92	18	86	73	15	75	16	75	74	87	4.60	−3.0	15	4,984	nw.	26	nw.	17	0	14	16	7.7	0.0	0.0
Colon	36	7	97	29.79	29.83	−.01	81.0	+0.8	90	20	86	73	14	76	13	76	75	85	12.31	−0.2	22	6,067	w.	25	e.	14	0	8	22	8.3	0.0	0.0
Alaska.																																
Juneau	80	11	54	29.83	29.92	.....	50.6	.....	65	4	56	35	21	45	23	48	46	89	16.46	.....	24	5,763	s.	40	se.	29	5	4	21	7.7	0.0	0.0

TABLE II.—*Data furnished by the Canadian Meteorological Service, September, 1923.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125	29.87	30.01	+0.04	52.7	−1.3	60.2	45.2	75	33	2.93	−0.78	0.0
Sydney, C. B. I.	48	30.04	30.09	+.08	55.9	−0.6	63.7	48.2	73	32	3.50	+0.22	0.0
Halifax, N. S.	88	29.98	30.08	+.04	58.0	−0.4	66.6	49.5	80	33	2.64	−1.07	0.0
Yarmouth, N. S.	65	30.02	30.09	+.04	55.9	−0.2	63.9	47.8	73	40	3.23	−0.22	0.0
Charlottetown, P. E. I.	38	30.01	30.05	+.04	56.6	−0.7	64.2	49.0	72	38	1.65	−1.75	0.0
Chatham, N. B.	28	29.98	30.01	+.01	55.2	−0.2	62.5	48.0	72	42	2.62	−0.09	0.0
Father Point, Que.	20	30.02	30.04	+.06	47.5	−2.9	55.9	39.1	73	27	1.80	−1.33	0.0
Quebec, Que.	296	29.77	30.09	+.08	56.4	+1.3	64.2	48.7	77	36	3.62	−0.05	0.0
Montreal, Que.	187	29.86	30.06	+.02	59.1	+0.7	67.2	51.0	82	39	1.58	−1.72	0.0
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.82	30.08	+.04	60.4	+3.0	71.0	49.9	83	34	1.78	−0.91	0.0
Kingston, Ont.	285	29.78	30.09	+.05	61.3	+1.3	68.7	53.9	82	38	2.19	−0.61	0.0
Toronto, Ont.	379	29.68	30.08	+.02	60.7	+1.7	69.3	52.0	85	37	2.67	−0.58	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.72	30.03	+.05	51.5	+1.2	63.5	39.6	77	25	3.03	+0.26	2.0
Port Stanley, Ont.	592	29.47	30.11	+.05	59.9	+0.4	67.9	51.9	80	34	1.78	−0.95	0.0
Southampton, Ont.	656	29.38			58.7	+1.2	66.5	50.8	80	34	3.55	+0.61	0.0
Parry Sound, Ont.	688	29.39	30.07	+.04	57.6	+1.6	67.1	48.1	82	33	3.53	−0.14	0.0
Port Arthur, Ont.	644	29.34	30.05	+.07	52.9	+0.7	60.8	45.0	79	33	2.68	−0.80	0.0
Winnipeg, Man.	760	29.13	29.95	+.01	58.8	+6.3	70.7	47.0	87	27	1.09	−0.94	0.0
Minnedosa, Man.	1,690	28.16	29.97	+.03	55.0	+4.5	67.9	42.1	88	18	0.81	−0.55	0.0
Le Pas, Man.	860				51.1		62.8	39.5	79	21	1.57		0.0
Qu'Appelle, Sask.	2,115	27.71	29.94	+.02	54.7	+3.6	67.2	42.3	86	22	0.76	−0.57	0.0
Medicine Hat, Alb.	2,144	27.69	29.93	+.01	59.6	+4.6	75.5	43.7	91	31	0.01	−1.17	0.0
Moose Jaw, Sask.	1,759				55.9		70.1	41.6	90	20	1.39		0.0
Swift Current, Sask.	2,392	27.43	30.04	+.12	55.0	+1.9	70.8	39.3	89	26	0.01	−1.21	0.0
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.46	30.01	+.08	50.1	+4.3	66.0	34.3	82	24	2.15	+0.48	4.8
Edmonton, Alb.	2,150	27.69	29.96	+.06	52.9	+3.6	66.9	38.9	85	25	0.95	−0.38	0.0
Prince Albert, Sask.	1,450	28.44	30.01	+.11	52.8	+4.4	64.3	41.4	76	27	1.03	−0.25	0.0
Battleford, Sask.	1,592	28.24	29.97	+.07	54.7	+2.9	69.8	39.6	88	26	0.45	−0.80	0.0
Kamloops, B. C.	1,262	28.80	30.09	+.12	58.4	+1.0	70.8	46.0	84	33	0.67	−0.18	0.0
Victoria, B. C.	230	29.79	29.97	−.04	58.4	+3.6	66.5	50.2	81	44	1.44	−0.72	0.0
Barkerville, B. C.	4,180	25.75	30.05	+.07	50.7	+4.0	66.2	35.2	73	23	2.77	−0.14	T.
Prince Rupert, B. C.	170				55.9		63.2	48.6	76	40	8.78		0.0
Hamilton, Bermuda.	151												

SEISMOLOGICAL REPORTS FOR SEPTEMBER, 1923.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, November 3, 1923.]

TABLE 1.—*Noninstrumental earthquake reports, September, 1923.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
	H. m.	**ARIZONA.**	° ′	° ′			*Sec.*			
Sept. 30	18 *ca*	Gisela	34 10	111 00	4?					Rachel Hickox.
	18 15*ca*	Pine	34 20	111 25	4?		2		Also felt at Payson	D. G. Goodfellow.
	18 27	Roosevelt	33 40	111 00	2	2	2	Rumbling	Felt by several	F. W. Crokin.
	18 45	Payson	34 10	111 00	4	1	1–2	do	do	R. C. James.
		CALIFORNIA.								
Sept. 3	12 19	Eureka	40 48	124 10	3	1	1	None	Awakened people	J. M. Jones.
6	12 *ca*	Santa Rosa	38 30	122 45	3	1	3*ca*		Awakened a few	M. W. Allen.
17	9 26	Eureka	40 48	124 10	3	2	2, 1	None	Felt by many	L. B. Cooper.
19	23 ..	Los Gatos	37 12	121 58	3–4	2	Brief.	do	do	I. H. Snyder.
22	0 50	Yorba Linda	33 50	117 45	3	1		do		P. J. Ton.
30	21 35	Calexico	32 41	115 30	4			do	Felt by several	R. Bradley.
		UTAH.								
Sept. 7	18 39	Richmond	41 55	112 10	4	1	30	Faint	Felt by many	J. R. Thomson.

TABLE 2.—*Instrumental seismological reports, September, 1923.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1923.]

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1		O	2 57 58				6,980	
		eP_E	3 08 25	3				P is very faint and uncertain. The distance is too great for the probable location of the epicenter.
		eP_N	3 08 25					
		S_E	3 16 53	16				
		S_N	3 16 53	18				
		eL_E	3 26 19	30				
		eL_N	3 23 25	28				
		M_E	3 38 51	18	*16,700			
		M_N	3 38 49	17		*6,200		
		C_E	3 51 ..	16				
		C_N	3 55 ..	15				
		F_E	6 38 ..	15				
		F_N	6 48 ..	13				
2		O	2 46 45				6,460	
		P_E	2 56 40					
		P_N	2 56 45					
		eS_E	3 04 52	21				
		S_N	3 04 46	15				
		e_N	3 11 30					
		e_E	3 13 52					
		L_E	3 14 48	24				
		L_N	3 14 59	20				
		M_E	3 26 36	18	*600			
		M_N	3 21 41	18		*900		
		C_E	3 32 ..	16				
		C_N	3 24 ..	18				
		F_E	4 58 ..	14				
		F_N	4 51 ..	15				
2		e_E	9 58 19					Very faint long waves.
		e_N	9 44 48					
		F	10 14 ..					
9		eP_E	22 27 31	8				Phases very poorly defined.
		eP_N	22 27 26					
		eS_E	22 33 47	10				
		eS_N	22 33 22	10				
		eL_E	22 50 27	28				
		eL_N	22 52 12	22				
		M_E	23 02 ..	16	*200			
		M_N	22 53 ..	22		*200		
		C	23 06 ..	16				
		F_E	23 27 ..					
		F_N	23 26 ..	16				
22		e_E	21 43 07	20				
		e_N	21 42 37	20				
		F_E	22 07 ..	15				
		F_N	22 00 ..	15				
23		e_N	17 21 22	4				Phases not well defined.
		eP_E	17 23 11	9				
		eP_N	17 22 45	9				
		e_E	17 29 27					
		eL_E	17 33 21	16				
		eL_N	17 32 26	16				
		M_E	17 47 31	11	*100			
		M_N	17 35 16	11		*200		
		C_N	17 41 ..	15				
		F_E	18 07 ..					
		F_N	18 09 ..	16				
26		eP_E	8 30 07					Very faint; eP_E may be microseismic.
		e_E	8 34 35	5				
		eL_E	9 02 27	18				
		eL_N	9 01 ..					
		F	9 13 ..					
30		O	1 20 26				6,260	P obscured by microseisms. Distance from L_N–S.
		S_E	1 38 02					
		S_N	1 38 02	14				
		eL_E	1 50 00	16				
		L_N	1 47 54	15				
		e_E	1 54 25	12				
		e_N	1 55 53	12				
		$M1_N$	1 51 34	15		*1,000		
		M_E	1 55 10	12	*1,100			
		$M2_N$	1 56 16	12		*800		
		C_E	2 05 ..	12				
		C_N	2 03 ..	13				
		F_E	2 40 ..	12				
		F_N	2 41 ..	12				

* Trace amplitude.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1		O	2 58 42				9,600	
		P_E	3 11 22	4				
		P_N	3 11 29	4				Not in good adjustment.
		S_E	3 22 01	10				
		S_N	3 22 09	7				
		eL_E	3 34 35	34				
		eL_N	3 34 44	26				
		e_E	3 45 26	19				
		M_E	3 50 20	18	*5,500			
		M_N	3 37 14	20		*800		
		C_E	3 51 ..	17				
		F_E	6 05 ..	15				
		F_N	4 35 ..					
2		O	2 46 23				9,675	Distance from L_E-S_E. N not in good adjustment; only slight evidence of waves.
		e_E	3 02 55					
		S_E	3 09 53					
		e_E	3 22 47	28				
		L_E	3 28 49	22				
		M_E	3 32 00	20	*700			
		C_E	3 36 ..	18				
		F_E	4 32 ..	16				
23		eP_E	3 48 17	2				Local shock.
		L_E	3 48 35					
		eL_N	3 49 34	4				
		M_E	3 48 47		*100			
		F_E	3 56 ..					
		F_N	3 50 ..					
30		O	1 20 49				6,400	Distance from L_N-S_N.
		eP_N	1 31 05	3				
		$ePR1_E$	1 33 18	4				
		eS_E	1 39 00	8				
		S_N	1 38 41					
		$SR1_E$	1 44 09	14				
		L_E	1 48 46	20				
		L_N	1 48 46	12				
		M_E	1 54 50	18	*5,000			
		M_N	1 54 47	15		*600		
		C_E	1 59 ..	14				
		C_N	1 59 ..	10				
		F_E	2 32 ..					
		F_N	2 11 ..					
30		P	18 28 14	1	*100			Local shock.
		F_E	18 32 45					
		F_N	18 29 20					

*Trace amplitude.

CALIFORNIA. *Theosophical University, Point Loma.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 11					50	50		Tremors during 24 hours preceding 15 *h.*
23					50	50		
24					50	100		
25					50	20		
26					100	50		
30					50	50		

COLORADO. *Regis College, Denver.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1923.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 7		L_E	4 23 ..					Very small sinusoidal: nothing on NS.
		M_E	4 30 ..					
		F_E	4 35 ..					
30		P_E	1 29 ..					Preliminaries very indistinct.
		L_E	1 45 ..	17				
		L_N	1 45 ..	17				
		M	1 49 ..	12	3	4		
		C_E	1 57 ..					
		C_N	2 02 ..					
		F	2 16 ..					*Instrument being repaired on Sept. 1.*

TABLE 2.—*Instrumental seismological reports, September, 1923*—Continued.

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

1923		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	P	3 12 21				9,600	Japan.
	PR1	3 16 15					
	S	3 23 01					
	L	3 41 42	54				
	L	3 45 30	40				
	L	3 51 ..	28				
	L	3 56 ..	20				
	L	4 00 ..	16				Long continued.
	F	7 *ca.*					
2	PR1?	3 04 04					
	S	3 10 56					
	L	3 26 20					
	L	3 29 ..	18				
	L	3 52 ..	16				
	F	4 50 *ca.*					
2	P?	9 41 28				9,900	
	PR1	9 44 34					
	S	9 51 21					
	L	10 24 ..	20				
	L	10 31 ..	16				
	F	10 45 ..					
2	P	22 47 31					
	S	22 55 05					
	F	23 25 ..					
9	P	22 23 33					
	S?	22 32 56					
	eL	23 00 00					
	L	23 11 ..	20				
	L	23 18 ..	16				
	F	23 40 *ca.*					
16	e	16 55 49					
	eL	17 40 ..	24				
	L	17 45 ..	20				
	F	18 *ca.*					
22	e	12 52 39					
	F	13 *ca.*					
23	eL	17 55 30	14				
	F	18 10 ..					
30	PRI	1 29 00					
	P	1 27 33					
	S	1 33 00					
	L	1 37 00	20				
	F	2 40 ..					

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1923.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	O	2 58 28				6,360	$M2_E$ is an estimated value as the spot of light went off the paper in one direction. The motion was so rapid as a result of the large amplitude of the swing after S that L could not be picked out.
	P_E	3 08 22	6				
	P_N	3 08 17	9				
	S_E	3 16 22	11				
	S_N	3 16 08	25				
	$SR2_E$	3 21 23					
	$SR2_N$	3 21 30	24				
	$M1_E$	3 25 ..	18	890			
	M_N	3 25 ..	18		1,000		
	$M2_E$	3 47 ..	17	1,160			
	F_E	9 15 ..	14				
	F_N	9 22 ..	12				
2	O	2 46 45				6,100	
	P_E	2 56 20					
	P_N	2 56 24					
	S_E	3 04 00	18				
	S_N	3 04 06	13				
	e	3 09 28	22				
	e_E	3 12 28	11				
	L_N	3 13 28	10				
	eL_E	3 14 38	19				
	M_E	3 15 58	19	184			
	M_N	3 13 36	10		120		
	C	4 02 ..	16				
	F	6 27 ..					
2	O	9 26 53				6,110	
	P	9 36 30					
	S	9 44 12	10				
	e_N	9 46 18					
	$SR1_N$	9 49 37	30				
	e_E	9 52 08					
	e_N	9 52 00	13				
	eL_E	9 54 14	22				
	eL_N	9 55 07	22				
	M_E	9 56 23	20	29			
	M_N	9 57 15	11		13		
	F_E	11 12 ..	15				
	F_N	11 13 ..	12				

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

1923.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 2	e_N	23 02 ..					E observed by overlap.
	F_N	24 31 ..					
9	O	22 18 40				6,025	
	P	22 28 12					
	S_E	22 35 49	12				
	S_N	22 35 50					
	eL_E	22 46 51	30				
	eL_N	22 46 40	45				
	M_E	23 01 50	20	29			
	M_N	22 49 30	30		63		
	F_E	24 28 ..					
	F_N	24 30 ..					
12	P_E	6 07 50					
	eL	6 11 08					
	M_E	6 13 30	18	48			
	M_N	6 11 30	18		24		
	F_E	6 23 ..					
	F_N	6 20 ..					
16	eP_E	16 54 14					
	eP_N	16 54 20					
	eL_E	17 05 33	22				
	eL_N	17 06 15	21				
	M_E	17 12 14	17	32			
	M_N	17 10 16	16		13		
	F_E	17 36 ..					
	F_N	17 39 ..					
17	e_N	8 17 ..					
	F_N	8 26 ..					
22	e_E	15 21 12					
	e_N	15 22 01					
	F_E	15 38 ..					
	F_N	15 30 ..					
22	eP_E	18 27 52	4				
	eL_E	21 41 28	42				
	eL_N	21 42 28	42				
	M_E	21 55 58	22	23			
	M_N	22 05 35	19		21		
	F_E	22 29 ..	17				
	F_N	22 24 ..	15				
23	e	17 44 ..					
	F	18 12 ..					
26	e_E	8 38 08					
	e_N	8 39 17					
	S	8 41 12					
	e_N	8 47 11	15				
	L_E	8 48 43	18				
	L_N	8 48 47	15				
	M_E	8 50 09	12	24			
	M_N	8 51 41	12		27		
	F_E	10 01 ..	8				
	F_N	10 01 ..	10				
27	P	7 22 13					
	F_E	8 05 ..					
	F_N	7 52 ..					
28	e_E	21 34 22					
	F_E	21 55 ..					
30	O	1 21 01				10,360	
	eP_E	1 34 23					
	eP_N	1 34 17					
	S_E	1 45 31					
	S_N	1 45 38					
	e_E	1 58 31	30				
	e_N	1 58 27	20				
	L_N	2 03 30	39				
	M_E	2 10 53	16	28			
	M_N	2 10 31	16		46		
	F_N	3 22 ..	15				

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1923.		*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	P	3 11 42				9,500	Japan.
	S	3 22 16					L not defined at first.
	ME	3 41 55		*20,000			
	MN	3 51 ..			*20,000		
	L	7 11 ..	18				
	L	8 26 ..	18				
	F	10 10 ..					
2	P	2 59 56				9,200	
	S	3 10 16					
	L	3 28 ..	25				
	L	3 33 ..	22				
	L	3 38 ..	16				
	F	6 40 *ca.*					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1923*—Continued.

ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 2		P	9 39 58				9,500	
		S	9 50 32					
		eL	10 09 30					
		L	10 18 ..	16				
		F	12 *ca.* ..					
2		P	22 49 33					P may be 22 : 48 : 36; much confused; may be two quakes superimposed.
		iS	22 55 58					
		i	22 57 46					
3		F	0 30 *ca.*					
9		e	3 30 43					
		S	3 34 33					
		L	3 38 33	16				
		F	5 *ca.* ..					
9		P	22 27 33				11,100	
		PR1	22 31 05					
		S	22 39 17					
		L	22 52 30	36				
		L	23 01 ..	30				
		L	23 07 ..	21				
		L	23 20 ..	15				
10		F	0 50 ..					
10		e	9 56 ..					
		F	10 25 *ca.*					
11		e?	9 22 ..					
		L	9 32 ..	16				
		F	9 42 *ca.*					
16		P?	16 55 30					
		S?	17 05 15					
		L	17 36 ..	24				
		L	17 44 ..	16				
		F	19 30 *ca*					
17		e	7 33 ..					
		eL	7 50 ..					
		L	7 55 ..	30				
		L	7 59 ..	22				
		L	8 04 ..	16				
		F	10 *ca* ..					
22		e	12 51 ..					No time.
22		P	21 05 45					
		S	21 14 50					
		L	21 31 ..					
		L	21 38 ..	28				
		L	21 48 ..	22				
		L	21 51 ..	16				
		F	23 40 *ca*					
23		P	17 43 15					
		S?	17 46 27					
		L	17 50 40	14				
		F	18 40 *ca*					
26		P?	2 43 58					
		S?	2 48 40					
		L	3 00 00	24				
		L	3 04 ..	16				
		F	3 30 *ca*					
26		P	8 40 34					
		S?	8 47 18					
		eL	9 08 ..					
		L	9 14 ..	15				
		F	10 30 *ca*					
28		P?	21 12 41					
		S	21 16 58					
		F	22 *ca* ..					
30		P	1 28 10				4,000	L lost in large movement. Irregular vibrations; period 14 sec. *ca.* from 2:20 on.
		S	1 33 55					
		M	1 40 *ca*		*28,000			
		F	5 20 *ca*					

*Trace amplitude.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 1		*O*	2 58 36				10,750	Distance derived from S_N–PR^1_N.
		eP_E	3 12 43					
		PR_{1E}	3 16 20	5				
		PR_{1N}	3 16 20	5				
		e_E	3 23 09					
		e_N	3 23 02					
		S_E	3 23 59					
		S_N	3 23 45					
		e_E	3 32 29					
		e_N	3 31 46					
		L_E	3 42 19	48				
		L_N	3 42 12	50				
		M_E	4 00 20	17	*2,000			
		M_N	4 05 10	17		*3,000		
		C_E	4 31 ..	16				
		C_N	4 32 ..					
		F_E	5 33 ..	15				
		F_N	6 15 ..					
2		*O*	2 46 12				11,200	
		ePR_1	3 04 25	5				
		ePR_{2E}	3 07 15					
		eS_E	3 11 45					
		eS_N	3 11 14					
		SR_1	3 18 53					
		eL_E	3 35 28	20				
		eL_N	3 35 44	20				
		M_E	3 57 20	16	*100			
		M_N	3 55 51	15		*100		
		F_E	4 30 ..					
		F_N	4 24 ..					
30		*O*	1 21 06				3,420	
		eP_E	1 27 43	3				
		eP_N	1 27 37	3				
		e_E	1 31 04					
		S_E	1 32 52					
		S_N	1 32 53	8				
		e_E	1 34 15					
		e_N	1 34 23					
		e_E	1 34 48	8				
		e_N	1 34 55					
		L_E	1 37 30	20				
		L_N	1 37 23	19				
		M_E	1 40 34	16	*6,000			
		M_N	1 41 20	14		*9,000		
		C	1 45 ..	15				
		F_E	2 21 ..	12				
		F_N	2 26 ..	10				

* Trace amplitude.

NEW YORK. *Fordham University, New York.*

1923.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 11		P						Obscured by micros.
		L	15 36 45		*200	0		
30		eP	1 26 41				3,500	NS not working properly.
		eS	1 31 44					
		L	1 35 16	28	*1,500			Irregular.
		M1	1 36 35	18	*3,200			Do.
		M2	1 27 23	16	*4,800			Do.
		M3	1 39 21	16	*5,400			Do.
		M4	1 40 51	13	*3.000			Do.
		C	1 50 ..		*9.200			
		F						Micros.

Chronograph being repaired Aug. 14 to Sept. 10; EW. component out of commission Sept. 26 to 29. Constants: Period, E, 5.7; N, 3.7. Magnification, E, 43x; N, 45x. Damping, E. 3.3; N, 3.7.

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1923*—Continued.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1923.			H. m. s.	Sec.	μ	μ	Miles.	
Sept. 1		P	3 20 00					Japan.
		M	4 00 00		*1,000	*1,000		
		F	5 30 00					
1								Slight tremors 22:12 to 22:15; local.
2								Slight tremors 22:45:00 to 23:04:00; probably Japan.
18								Slight tremors 19:27:22 to 19:28:06; local.
20								Slight tremors 17:35:12 to 17:36:52, 18:54:19 to 18:54:38, 20:30:27 to 20:31:00; local.
21		P_N	10 23 05				115*ca.*	Probably SW.
		S_N	10 23 28					
		S_E	10 23 31					
		L_N	10 23 46					
		L_E	10 23 51					
		M_N	10 23 40			*1,000		
		M_E	10 23 32		*1,000			
		F_N	10 28 14					
		F_E	10 26 11					
28		P_N	21 02 06				620*ca.*	
		P_E	21 01 58					
		S_N	21 03 54					
		S_E	21 03 46					
		L_N	21 04 54					
		L_E	21 04 44					
		M_N	21 04 56			*1,000		
		M_E	21 05 12		*500			
		F_N	21 15 00					
		F_E	21 11 00					
31		P_N	1 30 12				1,450	
		S_N	1 34 10					
		L_N	1 37 40					
		M_N	1 39 45			*500		
		M_E	1 39 26		*300			
		F_N	2 15 00					
		F_E	2 12 00					

* Trace amplitude.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1923.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1		eP_E	3 20 10					No definite phases.
		eP_N	3 19 20					
		e_E	3 27 10					
		e_N	3 30 36					
		$SR1_N$	3 35 48	38				
		eL_E	3 47 42	48				
		eL_N	4 06 02	22				
		M_E	4 16 20	18	*300			
		M_N	4 11 55	22		*2,500		
		C_E	4 20 ..	18				
		C_N	4 22 ..	18				
		F_E	5 30 ..	17				
		F_N	5 19 ..					
2		eL_E	3 49 11	24				Possibly a few long waves on N.
		M_E	3 55 21	22	*100			
		F_E	4 16 ..					
2		e_E	22 50 02					
		e_N	22 49 43					
		iP	22 50 05	3				
		L_E	22 52 32	11				
		L_N	22 52 36	10				
		M_E	22 50 07		*400			
		M_N	22 50 06			*600		
		$M2_E$	22 53 02		*300			
		F_E	23 02 ..					
		F_N	22 56 ..					
30		*O*	1 20 45				4,720	
		P_N	1 28 54	3				
		$PR2_N$	1 30 48	6				
		S	1 35 21	13				
		e_E	1 38 40	8				
		e_N	1 38 57	10				
		L_E	1 40 53	25				
		L_N	1 40 37	25				
		$M1_N$	1 35 33			*800		
		M_E	1 42 00	25	*300			
		$M2_N$	1 41 29	25		*300		
		C	1 44 ..					
		F_E	2 07 ..					
		F_N	2 05 ..					

* Trace amplitude.

VERMONT. *U. S. Weather Bureau, Northfield.*

1923			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1		eP	3 12 03				9,700	Japan.
		eS	3 22 46					
		L	3 41 22	40				
		L	3 54 ..	16				
		L	4 15 ..	14				
		F	6 15 *ca.*					
2		e	3 05 ..					
		S	3 10 44					
		eL	3 40 ..					
		L	3 45 ..	20				
		L	3 48 ..	16				
		F	4 30 *ca.*					
2		e	9 22 56					Phases indiscernible.
		L	9 23 02					
		F	9 23 20					
30		P	1 26 56				2,800	
		S	1 31 26					
		L	1 33 45	20				
		ME	1 37 ..		*37,000			
		L	1 43 ..	14				
		F	2 30 ..					

* Trace amplitude.

Reports for September, 1923, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
MASSACHUSETTS. *Harvard University*, Cambridge.
MISSOURI. *St. Louis University*, St. Louis.
NEW YORK. *Cornell University*, Ithaca.
CANADA. *Dominion Observatory*, Ottawa; *Meteorological Service of Canada*, Toronto *and* Victoria.

TABLE 3.—*Late reports (instrumental).*

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

1923.			H. m. s.	Sec.	μ	μ	Km.	
July 4		e_N	8 21 ..					Difficult.
		F	8 40 ..					
7		e	6 31 56					e possibly sooner.
		L_E	6 35 29	11				Heavy micros.
		F	6 40 ..					
10		eP_N	0 40 16					P_E does not show.
		iS_E	0 49 20					
		eS_N	0 49 20					
11		e_N	11 31 ..					EW time off.
		S_N	11 38 25					Heavy micros.
		eL_N?	11 52 24					
		L_N	12 15 ..	27				
		L_N	12 19 ..					
		F	13 10 ..					
12		e_N	9 38 58					
12		eL_N	4 05 00					Very heavy micros.
		L_E	4 13 ..	22				
		L_N	4 17 ..	22				
		F	4 37 ..					
16		L_N	16 05 04	16				Do.
		F	16 30 ..					
16		e_N	23 46 ..					Possibly not seismic.
17		F	0 04 ..					
17		e_E	1 10 49					Difficult.
		e_N	1 27 14					EW time off.
		F	1 45 ..					
18		e_N	1 18 47					Very faint.
20		e_N	15 16 ..					Very heavy micros.
		eS_N?	15 23 13					
		F	15 30 ..					
23		eP?	7 38 00					Do.
		iS_E	7 47 13					No other phases show.
		iS_N	7 47 23					
		F	8 30 ..					
22		P	14 29 25					
		S	14 38 35					
		eL_E	14 52 30	27				
		eL_N	14 53 12	26				
		L_E	15 01 43	16				
		L_N	15 00 29	16				
		M_E	15 04 05	16	*900			
		F	16 46 ..					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1923*—Continued.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1923.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 2		e	9 40 56	7				
		e_N	9 41 46					
		M_E	9 44 31	7	5			
		M_N	9 43 26	8		4		
		F	9 50 ..					
3		e_E	10 39 12					
		e_N	10 40 50					
		F_E	10 45 40					
		F_N	10 48 30					
5		e_E	1 29 10					
		e_N	1 29 55					
		M_E	1 32 20	13	4			
		M_N	1 32 05	13		2		
		F	1 40 ..					
5		e_E	10 40 00					
		e_N	10 36 42					
		M_E	10 42 45	13	5			
		M_N	10 41 30	11		2		
		F	10 51 ..					
8		e	8 47 20					
		F	9 00 ..					
10		eP_E	22 25 04				5,325	N partly obscured by overlap.
		eS_E	22 32 04					
		eS_N	22 33 38					
		L_E	22 39 50	12				
		L_N	22 39 50	15				
		M_E	22 43 25	12	10			
		M_N	22 43 19	13		10		
		F_E	23 30 ..					
		F_N	23 28 ..					
11		eP_E	1 07 28				8,430	Do.
		e_N	1 11 49					
		S_E	1 17 16					
		S_N	1 17 10					
		L_E	1 32 45					
		M_E	1 32 58	27	17			
		M_N	1 17 30	10		3		
		F_E	2 16 ..	16				
		F_N	2 18 ..	16				
12		P	10 25 39					
		e_E	10 37 43					
		e_N	10 33 50					
		M_E	10 47 30	17	10			
		M_N	10 53 00	15		1		
		F_E	11 21 ..					
		F_N	11 16 ..					
15		e_E	7 03 24					
		e_N	7 04 49					
		M_E	7 19 00	16	1			
		M_N	7 15 00	16		1		
		F_E	7 41 ..					
		F_N	7 29 ..					
17		e_N	1 50 31	18		1		E obscured by overlap.
		F_N	2 05 ..					
17		P_E	12 26 57	10				
		P_N	12 27 04					
		eS_E	12 34 12	15				
		eS_N	12 33 35	20				
		$SR1_E$	12 36 02					
		M_E	12 37 40	13	20			
		M_N	12 37 34	13		30		
		F_E	13 37 ..	8				
		F_N	13 31 ..	8				
19		e_E	12 42 22	8				N not recording on account of misplaced drum.
		e_E	12 52 50	15				
		M_E	12 55 30	19	26			
		F_E	13 13 ..					
23		P	5 33 19					
		S_E	5 38 58	8				
		S_N	5 39 10	8				
		M_E	5 41 14	8	20			
		M_N	5 41 20	8		29		
		C_E	5 49 ..	6				
		C_N	5 47 ..	7				
		F	6 25 ..	8				
27		e_E	8 03 35					
		e_N	8 02 57					
		F	8 08 ..					
27		e_E	11 50 50					
		F_E	11 59 44					
28		O_N	23 15 11				4,830	E partly obscured by overlap.
		eP_E	23 23 00					
		P_N	23 23 28					
		S_E	23 29 49					
		S_N	23 30 01					
		L_E	23 34 35	23				
		L_N	23 33 58	14				
		M_E	23 38 22	9	59			
		M_N	23 40 56	8		72		
		C_N	23 52 ..	8				
		F_N	26 02 ..	8				

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Contd.

1923.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 31		e_E	12 35 54					
		e_N	12 34 12					
		M_E	12 48 22	10	4			
		M_N	12 46 25	15		6		
		F	13 04 ..					

Period of pendulums, 12 sec.; sensitivity, up to Aug. 16: E, 0.177, N, 0.209; after Aug. 16, E, 0.181; N, 0.215. Multiplication, 150.

CANADA. *Meteorological Service of Canada, Toronto.*

1923			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 1		L_E	5 24 22					Undulatory.
		to	6 29 00					
1		i	8 37 51	3				*E-W.*
		i	8 37 54	8				Sharp vibrations *up* to 8h. 39m.
		L	8 54 00					
		F	9 10 00					
		i	8 37 51					*N-S.* Not so decided as E-W.
2		eL	9 45 06					*E-W.*
		L	9 47 07					Small amplitude.
		F	9 54 00					
4		L_E	17 13 00					Undulatory.
			to 44 00					
8		L_E	9 04 00					Slightly undulatory.
			to 18 00					
8		L_E	12 03 00					Undulatory.
8		iP	12 08 20				3,720	*E-W.*
		S	12 13 51					
		eL	12 15 45					
		L	12 16 15					
		M	12 21 32	17	8			
		i	12 36 16					
		eL	12 46 08	23				
		F	13 48 00					
		O	12 01 24				3,680	*N-S.*
		iP	12 08 20					
		eS	12 13 48					
		iS	12 13 53					
		eL	12 17 11					
		L	12 18 20					
		M	12 22 15	17		11		
		i	12 36 15	8				
		F	13 34 00					
10		eL_E	3 02 23					Undulatory.
		L_E	3 16 08					NS component not affected.
		eL_E	3 45 22					
		F	?5 21 00					
10		L_E	16 46 30					Undulatory.
		eL_E	16 56 00					Nothing on NS.
		F						Micros.
10		L	23 12 45					*E-W.* Heavy micros.
		F	23 48 ?					
		L	23 12 45					*N-S.* Micros.
		L	23 16 00					
		F	23 44 00					
11		e	1 26 23					*E-W.* Micros, slow waves.
		i	1 33 08					
		L	1 52 15					
		F	3 12 00					
		i	1 17 08					*N-S.* Small amplitude.
		i	1 33 08					
12		e	7 07 15					*E-W.*
		F	7 24 00					
		e	7 10 37					*N-S.*
		L	7 16 00					
12		e	10 46 08					*E-W.*
		L	11 07 38					Slow waves.
		F	12 01 00					
		L	10 58 30					*N-S.*
		L	11 06 00					
		L	11 08 23					
			to 15 08			3		
		F	11 48 00					
12		e_N	17 43 48					Slight traces; local effects on EW.
		F_N	17 58 00					
16		i	20 44 41					*E-W.*
		L	21 03 08					
		L	21 06 52					
			to 13 00	23				
		F						Micros.

TABLE 2.—*Instrumental seismological reports, September, 1923*—Continued.

CANADA. *Meteorological Service of Canada, Toronto*—Continued.

Date			H. m. s.	Sec.	μ	μ	Km.	Remarks
1923. Aug. 16		i	20 44 34					*N–S.* Minute quivering at 20h. 44m. 34s.
		L	21 02 50					
		L	21 10 20					
		L	21 11 00					
		L	21 16 *to*					
			21 20 00					
		F						Micros.
17		e	1 24 20					*E–W.* Minute ripples at 1h. 24m. 20s.
		i	1 25 08	7				
		i	1 25 23					
		L	1 44 53					
		F	?2 20 00					
		e	1 24 05					*N–S.* Ripples at beginning.
		i	1 25 15					
		L	1 47 00					
		F	?2 21 00					
17		e_E	4 30 45					Nothing definite.
		L_N	4 34 22					
		F	4 52 00					
17		Le	12 14 45					Very small amplitudes. L, 12:38: 45. Nothing on NS.
		F	12 39 15					Micros.
17		L	13 12 *to*					*E–W.* Sinusoidal; early phases masked by local causes.
			13 17 23					
		L	13 18 53	23	7			
			to 37 00					
		F						Paper being changed.
		L	12 02 00					*N–S.*
		L	12 12 *to*	23		4		
			12 27 45					
		F	?13 54 00					
18		L	22 00 00					*E–W.* May not be seismic.
		L	22 36 05					
			to 37 37					
		F	23 08 45					
		L_N	22 36 00					
			22 47 00					

CANADA. *Meteorological Service of Canada, Toronto*—Continued.

Date			H. m. s.	Sec.	μ	μ	Km.	Remarks
1923. Aug. 19		eL	13 18 30					*E–W.* Early phases masked by local causes.
		L	13 26 00	23				
			to 32 30		7			
		L	13 38 18	18				
			to 41 00					
		F						
20		L_N	?19 12 37					Very small amplitudes.
		F	19 27 00					Local causes masked E W component.
23		P	5 29 16					*E–W.* S indefinitely recorded.
		eS	5 35 45					
		L	5 42 43					
		L	5 46 00	15		5		
		F	6 44 00					
		iP	5 29 11					*N–S.* S came in similar to a large wave.
		i	5 29 20					
		i	5 33 23					
		eS	5 35 45					
		L	5 43 04					
		L	5 46 37	18	6			
		L	5 50 00					
		to	5 54 00	10				
		F	6 40 00					
28		*O*	23 15 20					*E–W.*
		iP	23 21 30	3–8				
		eS	23 26 23	8–10				
		i	23 26 30	8–10				
		L	23 30 25					
		iL	23 31 35	7	232			Large vibrations.
		M	23 31 51	3			3,140	
			to 32 00	10				
		L	23 49 15	15				
		F	2 53 00					
		O	23 15 23				3,140	Marked, steady trending N, beginning 23:21:21, lasting 8 sec. Rapid vibrations during L.
		iP	23 21 33					
		iS	23 26 26	10				
		i	23 26 39	8				
		iL	23 30 30	11				
		L	23 31 08	15				
		M1	23 32 19	10		496		
		M2	23 32 44					
		M3	23 33 24					
		F	1 56 00					

Chart I. Tracks of Centers of Anticyclones, September, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

Chart I. Tracks of Centers of Anticyclones, September, 1923. (Inset) Departure of Monthly Mean Pressure from Normal. (Plotted by Wilfred P. Day.)

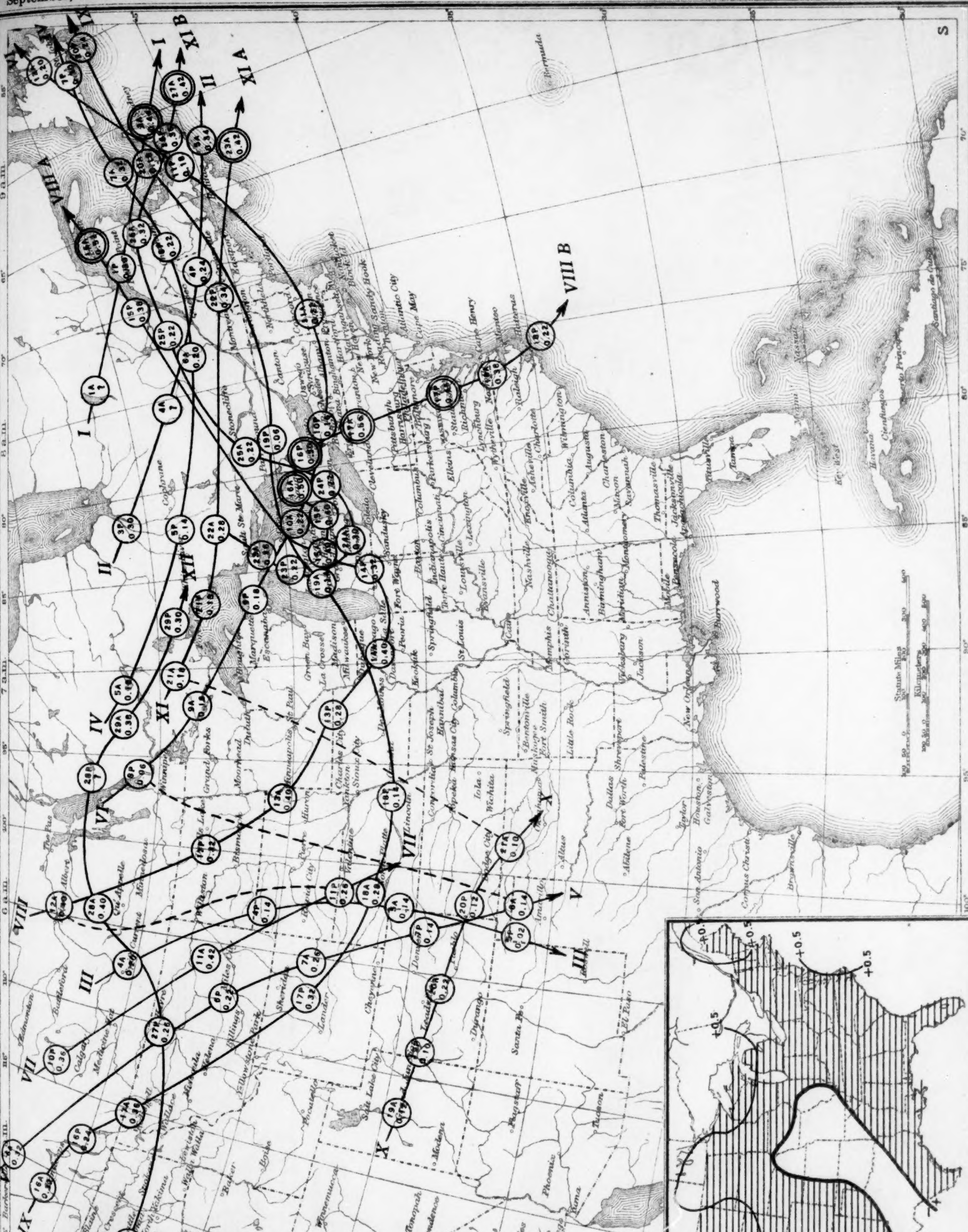


Chart II. Tracks of Centers of Cyclones, September, 1923. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

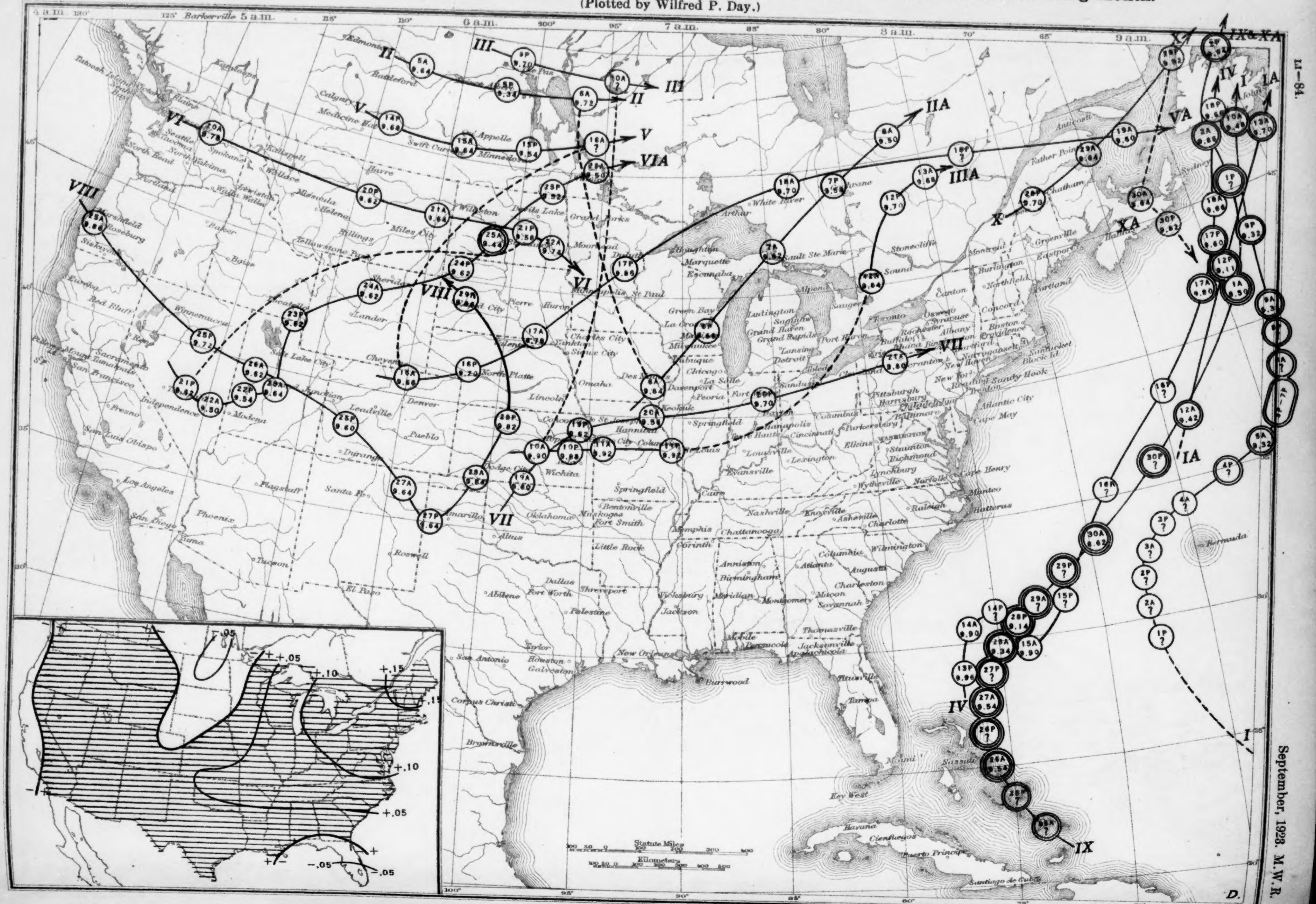
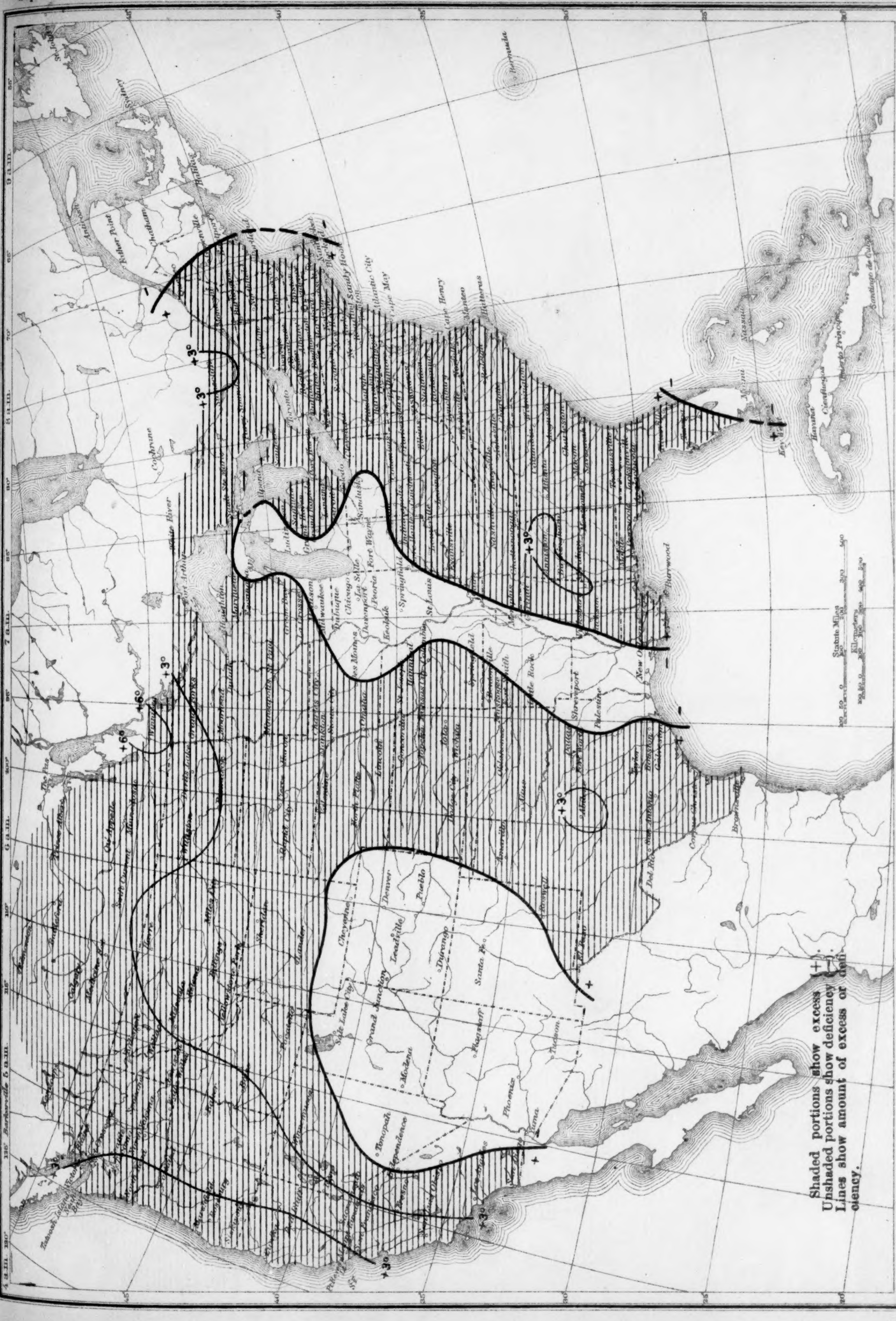


Chart III. Departure (°F.) of the Mean Temperature from the Normal, September, 1923.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, September, 1923.



Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart IV. Total Precipitation, Inches, September, 1923. (Inset) Departure of Precipitation from Normal.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, September, 1923.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, September, 1923.

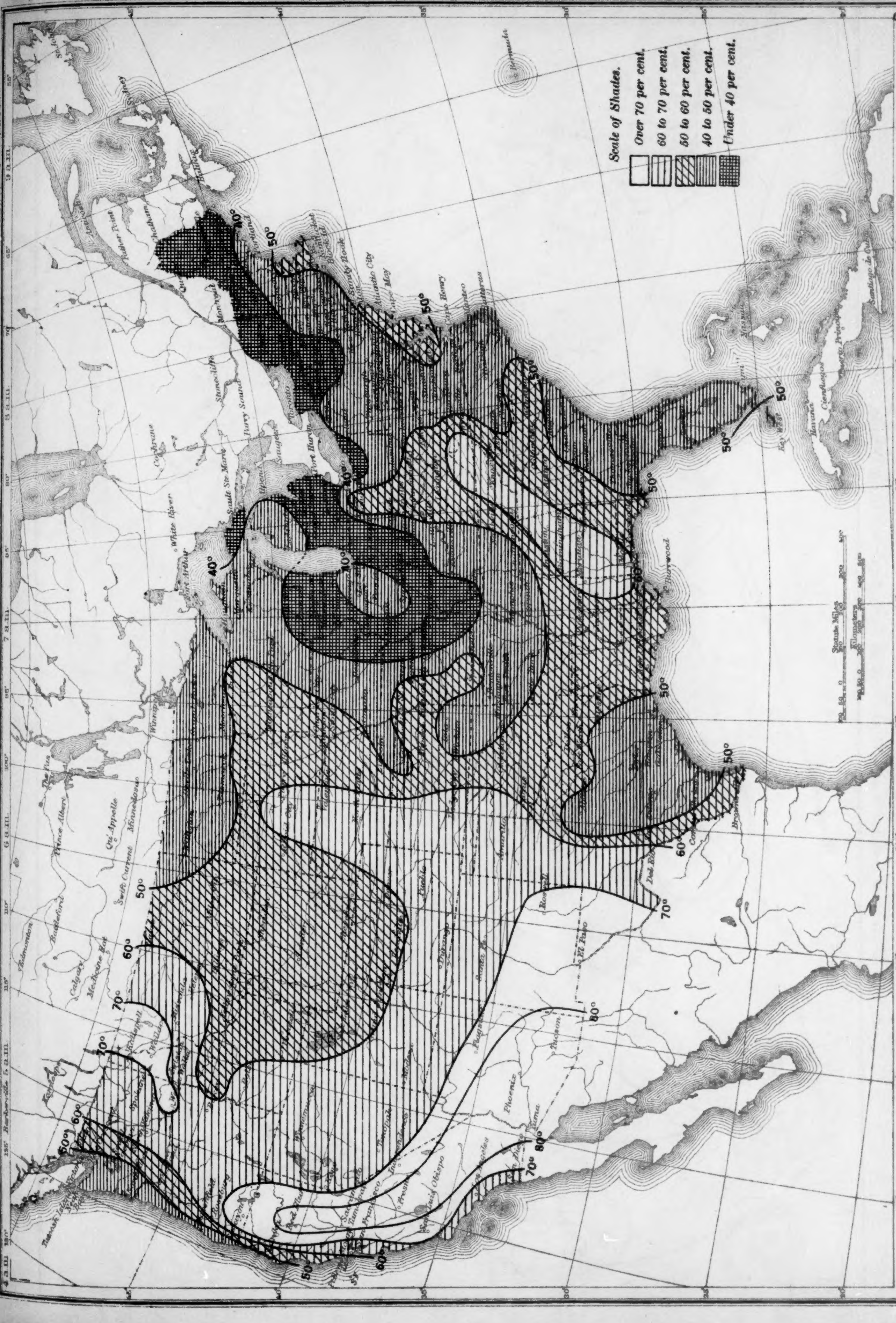


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, September, 1923.

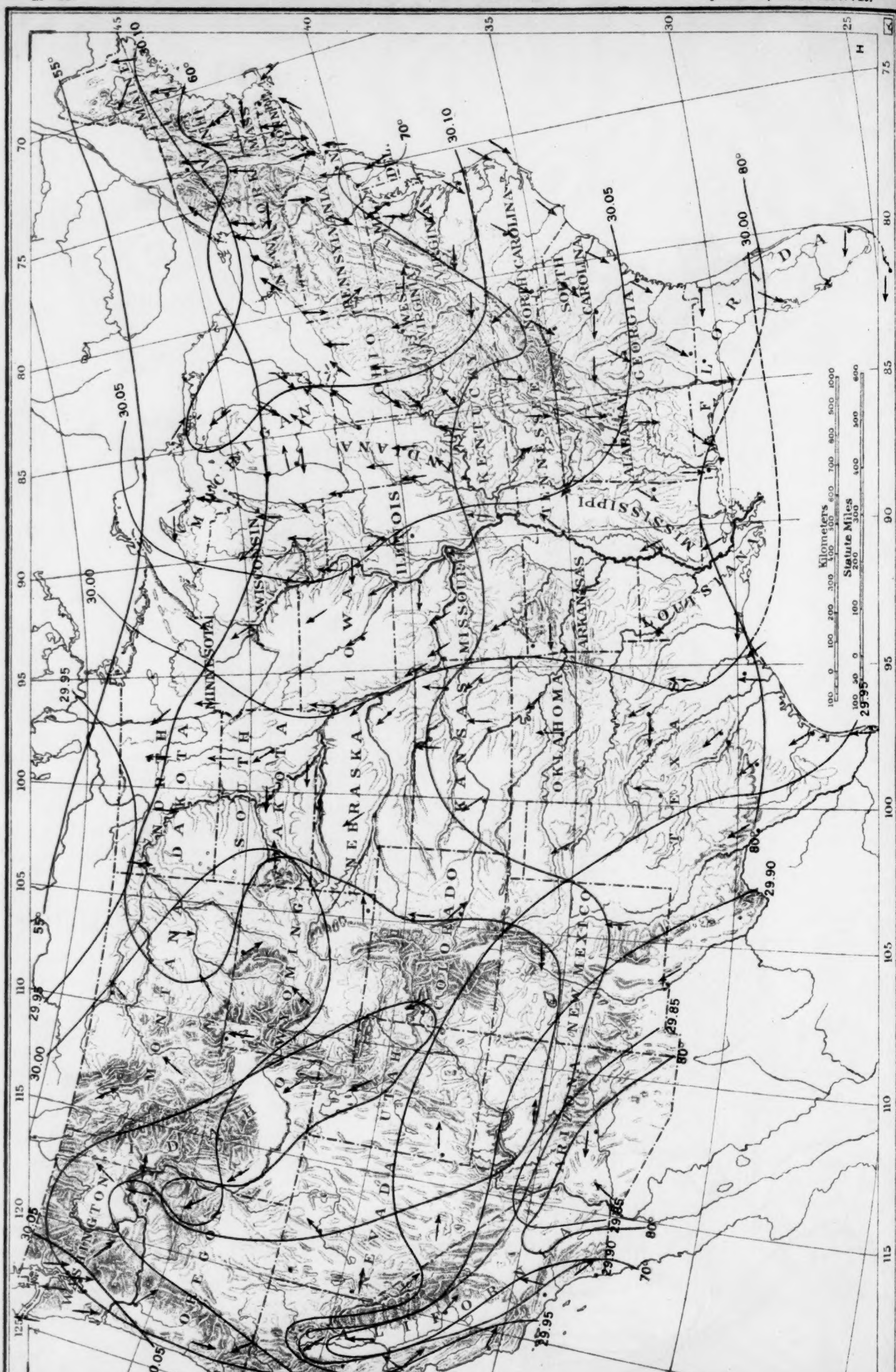


Chart VIII. Weather Map of North Atlantic Ocean, September 26, 1923.
(Plotted by F. A. Young.)

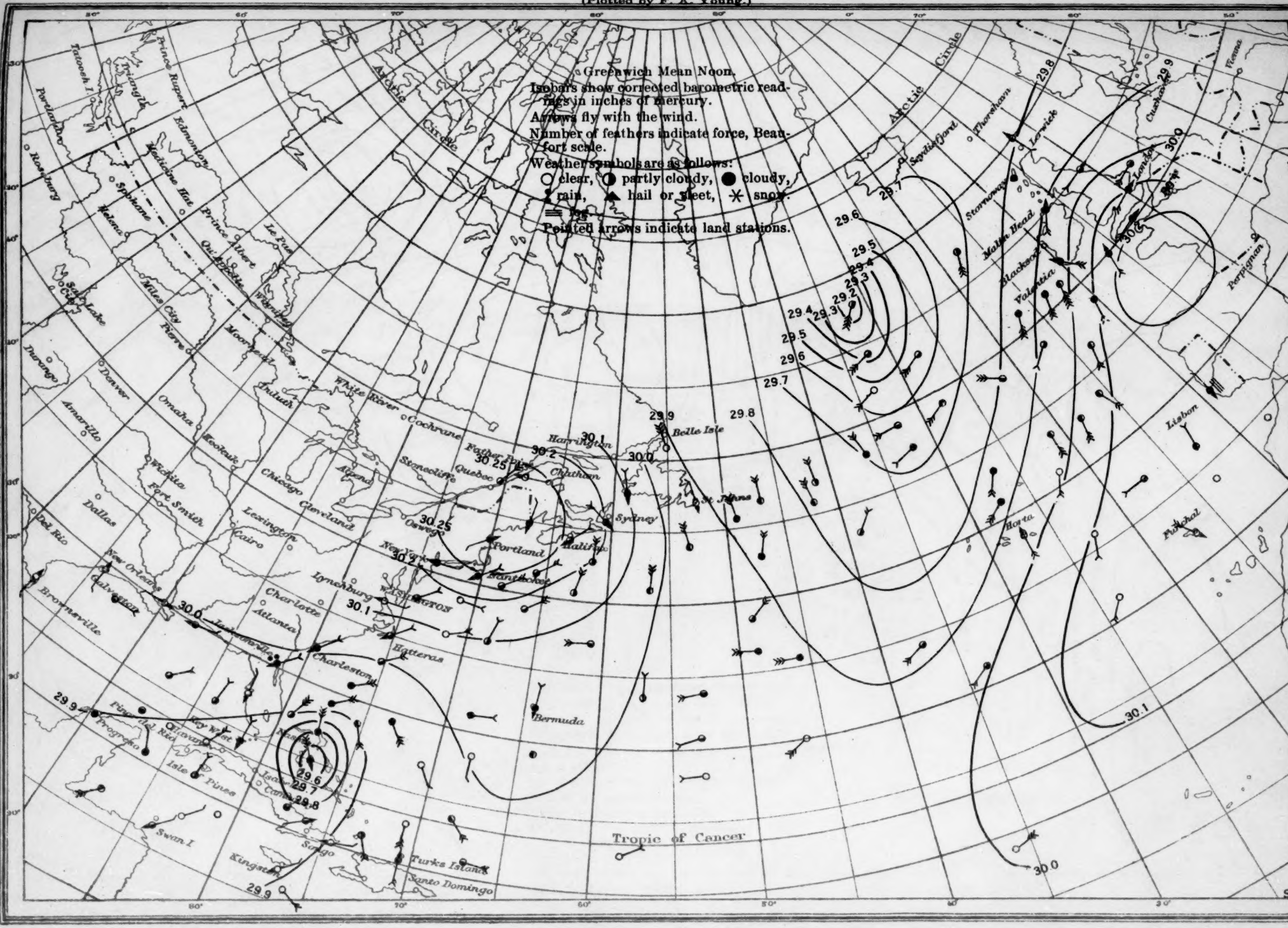


Chart IX. Weather Map of North Atlantic Ocean, September 27, 1923.
(Plotted by F. A. Young.)

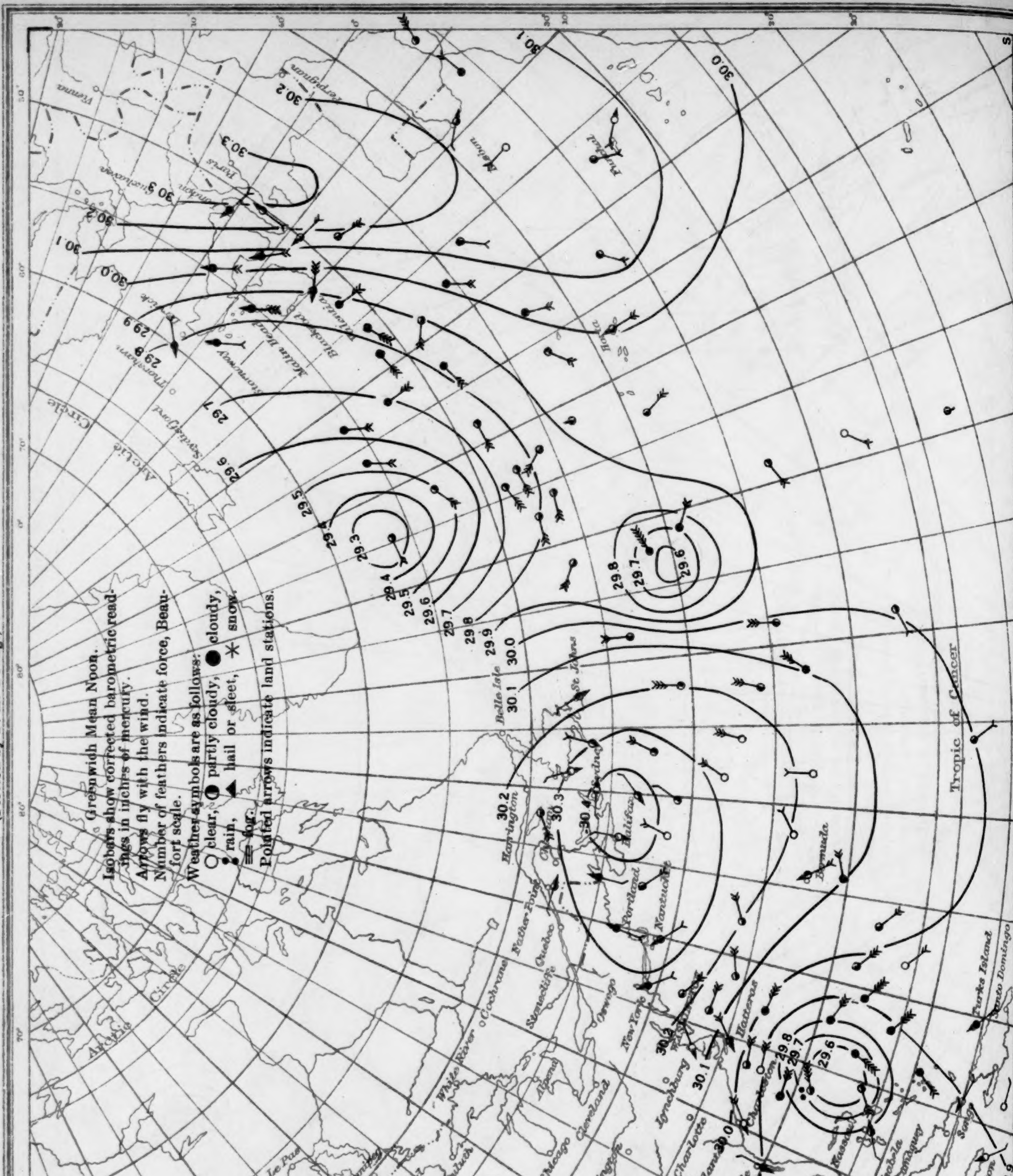


Chart X. Weather Map of North Atlantic Ocean, September 28, 1923.
(Plotted by F. A. Young.)

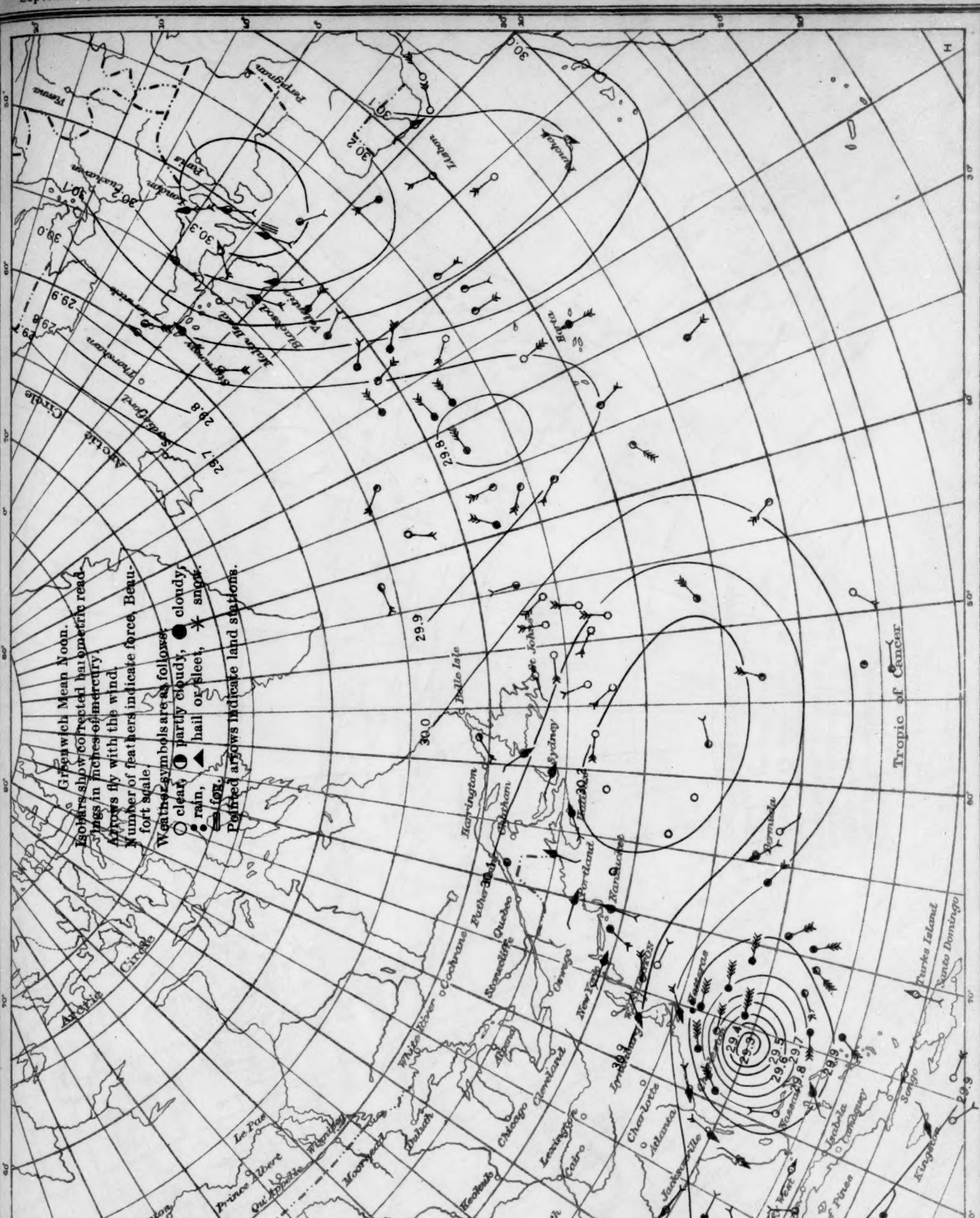


Chart XI. Weather Map of North Atlantic Ocean, September 29, 1923.

(Plotted by F. A. Young.)

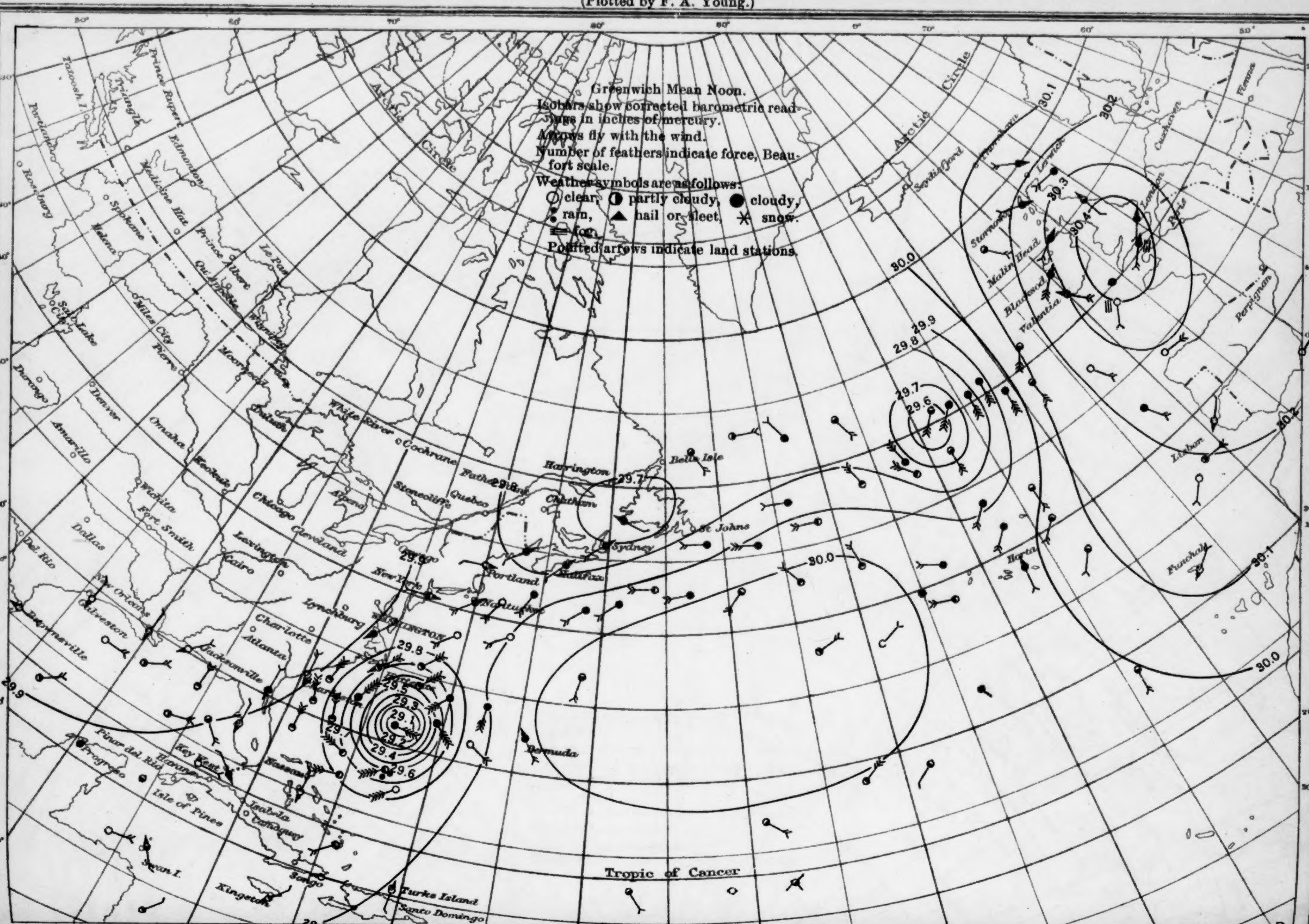


Chart XII. Weather Map of North Atlantic Ocean, September 30, 1923.
(Plotted by F. A. Young.)

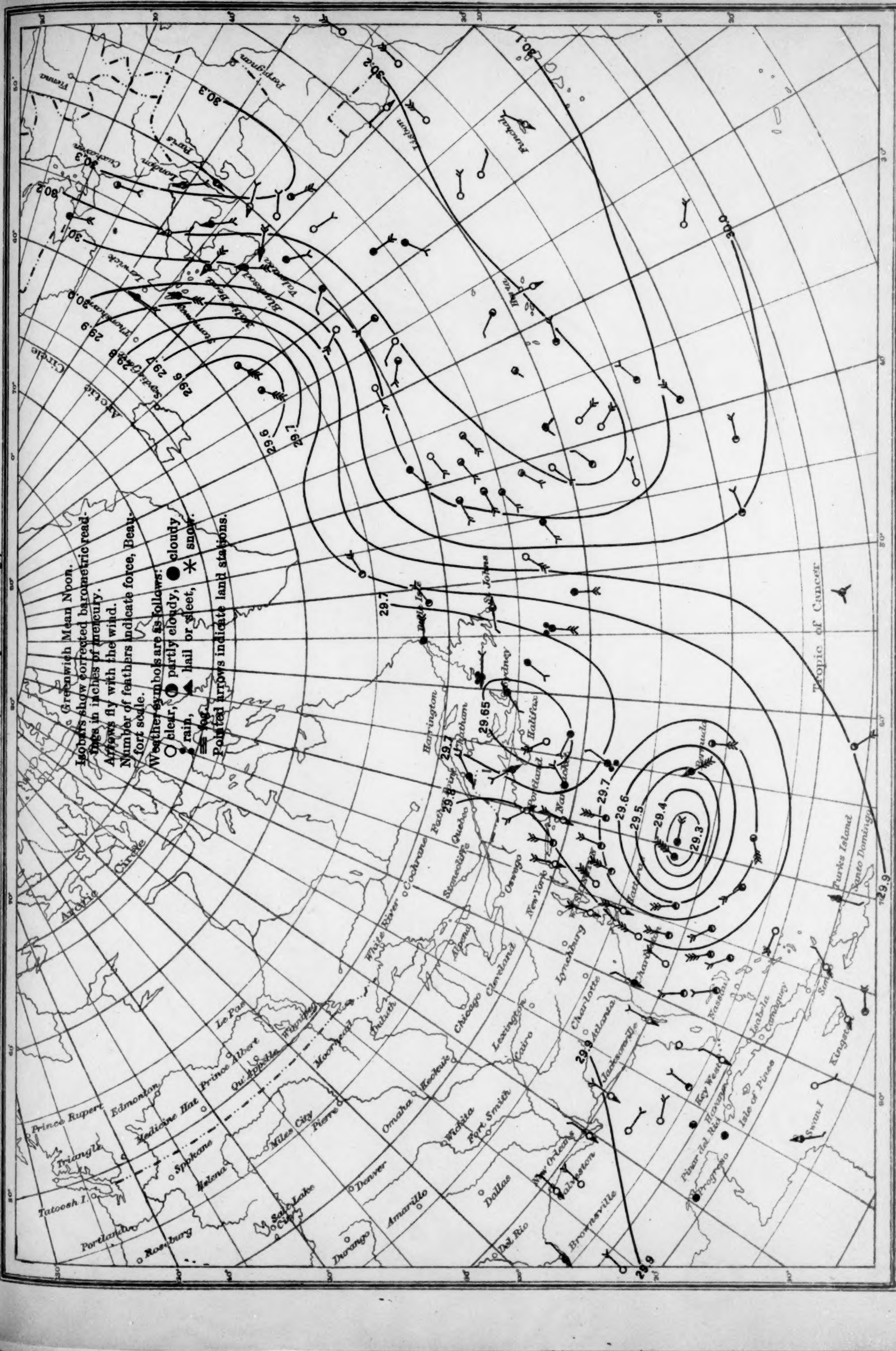


Chart XII. Weather Map of North Atlantic Ocean, September 30, 1923.
(Plotted by F. A. Young.)